ACUTE NASAL TRAUMA

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I hereby declare that this thesis presented for The Doctor of Medicine Degree at Edinburgh University in 1982 has been composed by myself and all the work is entirely my own unless otherwise stated.

Signature

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THE FRACTURED NOSE.

INTRODUCTION.

The nose is the most prominent part of the face and as such is very liable to be traumatised. A damaged nose is obvious to the onlooker, does little to help the person's self-image, may prove to be a great social inconvenience and on occasion, may lead to ill-health.

Nasal trauma has always been with us but interest has only recently been aroused regarding the best treatment. There is much in the pathogenesis and treatment of a fractured nose which requires to be investigated.

This thesis concerns different aspects of nasal trauma. All the observations were carried out on the human body or on human models as there is no adequate animal model to mimic the structure of the human nose in response to human trauma.

This thesis is divided into six Chapters. Chapter one is a fundamental review of the body of world knowledge of nasal fractures with emphasis on the wide reaching effects they may cause. The world literature, which is most relevant to the experimental work of this thesis, is included in the appropriate Chapter.

In Chapter two, it appears that the present state of treatment of nasal fractures is inadequate and the three subsequent Chapters attempt to clarify the reason for the poor end results of nasal manipulation.

In Chapter three, the actual fracture lines are mapped out from human cadaver experiments. Chapter four seeks to explain the reasons why the fracture lines run in this fashion. The mechanical behaviour of the cartilaginous septum after trauma is investigated in Chapter five to determine if any peculiar characteristic of the septum has a bearing on the cosmetic and functional results of operations on the post-traumatic nose.

In Chapter six, the information obtained in the previous Chapters is integrated and an alternative treatment is suggested to the accepted treatment which was found to be lacking in Chapter two. A critical appraisal of this alternative treatment of nasal fractures is undertaken.

CHAPTER ONE.

HISTORY OF THE TREATMENT OF FRACTURED NOSES.

The treatment of acute nasal trauma has not substantially changed for the past 5,000 years.

The earliest recordings of the deeds of the second oldest profession include data on the treatment of fractured noses (Breasted 1930). An unknown scribe in the Seventeenth Century B.C. copied an ancient document circa 3000 B.C. describing the diagnosis and treatment of a fractured nose in Ancient Egypt. The diagnosis was made from the evidence of disfigurement of the nose which was either a depression or swelling. Epistaxis was also inevitably present. The nose was cleared with two plugs of linen and thereafter another two plugs of linen saturated with grease were placed inside the nostrils. Time was allowed for the swelling to reduce and the patient was advised to rest during this period. Two stiff rolls of linen were then applied to the nose until it had 'set' thereafter, daily treatment with grease, honey and lint was instituted until recovery. Only after the nose had 'set' did the Surgeon clear the nostrils of coagulated blood.

If the nasal bones were markedly displaced, the bones were forced to "fall in" i.e. reduced and thereafter the coagulated blood was removed from the nostrils. Again an internal splint of grease soaked linen was used as well as an external splint of two stiff rolls of linen. A more severe fracture was also recognised.

If the patient had crepitation at the nasal fracture site with associated epistaxis together with a bleeding ear and painful jaw movements as a result of direct trauma to this area, the Ancient Egyptians suggested this was beyond their capabilities of treatment. They suggested conservative treatment for this condition presumably as it involved a base of skull fracture and was inevitably fatal.

Two Thousand, Five Hundred years ago in Ancient Greece, the fractured nose was the hallmark of the professional boxer. Previously, boxing had been a more respectable, gentle sport using well-padded gloves made of soft leather thongs. With the advent of professionalism, however, boxing degenerated to the level where pugnacious giants toured the country putting on exhibition bouts.

To earn the high rewards from this lifestyle, the boxer had to satisfy the public demand for violence. This was assured by the use of sharp-cutting gloves of hard leather. The fractured nose became the normal acquisition of such a boxer. Indeed, however, the shape of the broken nose was not uncommon throughout Greek civilisation. Some of the examples of Greek Sculpture which are still in existence, show evidence of a fracture of the nasal bones (MAJNO 1975).

The Father of Rhinology, Hippocrates, was renowned for his writings on nasal fractures as well as other nasal problems. He advocated early reduction of a nasal fracture - within 24-36 hours of the injury. If the fracture was compound, however, he washed the wound with urine until the skin had healed before any attempt was made to reduce the fracture.

A bronze spatula specifically made for this purpose was placed in the nostril and the bone was elevated. He used his fingers to guide the fragment into place. Internal splints of "carthaginian leather" wrapped around fluff scraped off a linen towel were used to stabilise the fracture from within.

The use of sponges as internal splints were condemned as they quickly became foul and could not be kept in position for the requisite ten days to allow the bones to set. If the nasal bones did not stay in the midline by themselves, the patient himself pushed the bones into position as often as he could until the fractures had set. Alternatively, Hippocrates used a long leather thong glued by some means to the point of the nose. The other end was pulled to the opposite side, wound around the head and fastened with glue to the temples. This thong could be slackened or tightened as necessary (Stevenson & Guthrie 1949, Adams 1849, Petrequin 1878). Hippocrates does state, however, that nasal fractures with dislocation of the nasal cartilage inevitably lead to deformity (De Moulin 1964).

The method of treatment of nasal fractures was similar during the Roman civilisation which merely reflects the lead from Greece. Celsus, made an attempt to unravel the complexities of rupture of the nasal cartilages with emphasis on meticulous skin suture (Adams 1849).

The exchange of ideas to the East from the Greek or Roman cultures is reflected in the writings of the most significant surgeon of the Hindu culture, Susruta, who probably lived about 400B.C. but there is no definite evidence of this.

Although better known for his techniques of rhinoplasty, Susruta was also interested in the treatment of the fractured nose. He probably reduced the nasal fractures as suggested by Hippocrates but used the more easily accessible material of bamboo as an internal splint to stabilise the fracture (MAJNO 1975).

There does not appear to be much information directly handed down from the Alexandrian School of Medicine which achieved a high degree of development in other types of surgery. Second-hand information on the writings of Amyntos (50 B.C.) does, however, tell us of his interest in fractured noses. (Mettler 1947).

THE DARK AGES.

Development of the treatment of nasal fractures in the subsequent millenium was poorly recorded. The bad results of the treatment of nasal fractures as noted by Hippocrates in 400 B.C. were re-affirmed in the 9th Century Codex Augiensis Cxx. (De Moulin 1964).

A description of nasal trauma and treatment in the Arabic civilisation was documented in 1013 A.D. by Albucasis. He suggested the lower portion of the nose was cartilaginous and hence unbreakable. A low nasal bone fracture could be elevated with the little finger inside the nostril but if the fracture was beyond this reach, a probe had to be used for the elevation. He suggested either the first post trauma day i.e. before the swelling had occurred or the seventh to tenth post-trauma day when the swelling had diminished, as the best times for reduction. This allowed accurate reduction of the fragments to the mid-line without misleading swelling. He introduced a linen pad soaked in egg white into one or both nostrils. As an alternative to pads, he suggested the use of stems of goose quills wound with a piece of soft cloth. An external plaster of white flour and frankincense stabilised the whole structure. If an abscess formed over the dorsum of the nose, however, cotton wool soaked in vinegar and oil of roses on a little diachylon ointment was put on the nose and covered with a wax plaster. For a compound fracture, he advocated removal of the fragments and suture of the cut. (Albucasis 1013).

THE RENAISSANCE.

Despite the advances made in appreciation of the aesthetic appearance of the human face which may be seen from the sketches and drawings of Leonardo Da Vinci, the treatment of the acutely traumatised nose received scant attention. The more pressing problem was the repair of the nose following the ravages of syphilis which was common in Europe at that time. The nose was reconstructed by a flap of skin taken from the arm (Paterson and Powell 1974).

The practice of amputation of the nose for adultery in Ancient India is said to have stimulated the development of the operation of rhinoplasty as described by Susruta. Amputation of the nose was also practiced in Ancient Egypt, however, and probably knowledge of the reparative operation was disseminated from there by itinerant Arabians (Garrison 1929, Castiglioni 1947). Further development of this technique became necessary from the duelling and warring of the Renaissance period; the Brancas and Tagliacozzi were in the forefront of this revival of interest. (Bettman and Henchi 1956).

The nose has always held respect throughout the ages but the degree of protection for the nose in war reflects more the type of weaponry used than the emphasis placed on the nose. The interest in nasal protection shown by the Ancient Greeks is evidenced by the 7th Century B.C. Etruscan helmet. As, however, development of more sophisticated techniques produced the long range missile i.e. the spear, so the need for nose protection lessened.

The nose protector of the Ancient Greeks, ideal to parry the side swipe of the sword, is replaced in the 17th Century A.D. with the retractable nose protector of the trooper's pot. The advent of musketry and later highly accurate long range rifles made any nasal protection superfluous.

Top Left: Corinthian Helmet from The Siege-Mound, Paphos. 498 B.C.

Top Right: Chalcidian Helmet from Near Salonika. 400 B.C.

Bottom Right: Corinthian Helmet of Late Type, Corinth.

Simple 'Trooper's' Pot without ear flaps, made from two pieces and one piece neck guard. Early 17th Century.

EIGHTEENTH AND NINETEENTH CENTURY.

The functional aspects of the nose do not appear to have achieved recognition until Quelmalz in 1750. He suggested the treatment for septal deflections to be daily massage of the septum back to its original position. The first operative procedures on the human nasal septum involved shaving down the convexities and even creating or ignoring perforations after the removal of acute angulations (Langenbeck 1843, Dieffenback 1845, Chassaignac 1851). Ruprecht (1868) even designed punch forceps for a through and through removal of angulations and Bosworth (1887) fashioned a saw for the excision of septal spurs. Krieg in 1889 progressed to removing cartilage and mucosa of the septum but suggested leaving one side of the mucosa intact from which new cartilage would regenerate. The classic submucous resection was not popularised until the twentieth century despite the probability that it was originated by Buckhardt (1887).

Freer in 1902 is usually given the credit for the first description of the submucous resection but undoubtedly, he was not the originator. Freer regarded the septum as being almost redundant in the nose and that the external framework did not need the support of the septal cartilage. In fact, he described an operation whereby the septum was repositioned after weakening it with a chisel cut.

Killian (1904) on the other hand, felt the septal cartilage was essential for support of the external cartilaginous framework. He developed the classic submucous resection. One year later, Freer described the sub-total removal of the bony septum using a chisel and punch forceps.

The alternative to removal of an offending malformed part of the septum was to mould the cartilage and bone back into shape, thereby retaining its supportive qualities.

Adams (1875) appreciated the importance of the septum and designed a pair of cartilage forceps whereby the septum was fractured and moved to the midline. The fractured segments were splintered and held in the straight position until healing had occurred. Asche (1891) likewise devised a suitable pair of forceps for septum manipulation into the midline.

Walsham (1890) designed a pair of bone forceps to grasp the fractured nasal bone on both sides, one prong being inserted into the nostril. This enabled the bone to be reduced accurately to its original position.

These latter three surgeons left a strong legacy on which is based the treatment of acute nasal trauma in the present day.

TWENTIETH CENTURY.

The explanation of the pathogenesis of facial trauma had to wait on the ingenuity of a Frenchman at the begining of this Century. Le Fort (1901) described three different types of major facial fracture. He produced these by hitting cadavar heads on the face with varying degrees of violence. Although the nose was damaged in these experiments, limited information on isolated nasal fractures was gleaned. One fracture, the Lefort II or pyramidal fracture, results when the nose is pushed inwards like a cork in the neck of a bottle.

This produces the nasal ethmoidal fracture which, at the time, rightly took precedence over the isolated nasal fractures. The clinical importance of facial fractures was appreciated fully in the First World War (Roberts and Kelly 1916, Gilles 1920). The long term results of undiagnosed or inadequately treated nasal fractures became evident during the inter-war period. (Sheehan 1936, Barsky 1938).

The twentieth Century "body beautiful" image propounded by the media deems that conformity to the ideal physique is necessary and there is a universal desire to avoid a disfiguring deformity to the most prominent part of the face. The earlier gross attempts at mere replacement of the fractured displaced portion where millimetres of inaccuracy may deem the treatment a failure are not acceptable in modern times. Formal rhinoplastic techniques may be necessary to exactly restore the shape of the nose either in the acute phase or in a late post-traumatic deformity.

THE PHILOSOPHY OF THE NOSE.

There is perhaps nothing so eloquent and significant as the human face. Leonardo Da Vinci believed the perfectly proportioned face should have its forehead, the tip of the nose and the chin touching the arc of a circle, the centre of which is at the external auditory canal. (Patterson and Powell 1974). Further detailed measurements are listed by Bernstein (1964). Females usually wish their nose to fit their face i.e. to be unprominent but yet to quote Francis Bacon "There is no excellent beauty which hath not some strangeness of proportion". Edmund Rostrand believed a great nose indicates a man who is great, genial, courteous, intellectual, virile and courageous. More recently, Huizing (1965) has pointed out the great significance of the shape of the nose as a means of characterisation in interpersonal relationships and in art. The nose is held by some to have a special significance in the unconscious mind of the individual (Palmer and Blanton 1952, Rumke 1950, Blair and Brown 1931).

The nose can be a symbolism of virility. The surrealist painter Barbara Millett and other painters/writers liken the fleshy protruberant nose to the human penis (Morris 1977).

Mutilation from trauma or surgery may well give to feelings of emasculation which highlights the suitability of the ancient Indian habit of amputating the nose as a punishment for adultery. (Bishop 1960).

GENERAL HEALTH.

In previous decades, a nasal septal deviation was thought merely to produce a blocked nose and hence the reason for a straightening operation.

More recently, however, investigations have shown that a blocked nose may lead to systemic upset of a serious nature. Many authors have previously hinted that there may be some link between nasal and pulmonary physiology but it was not until Ogura described an elegant series of experiments that this theory gained worldwide acceptance.

Twenty subjects with nasal obstruction had their lung compliance and pulmonary resistance measured. Following an operation to relieve the nasal obstruction, the compliance and resistance values were found to have improved considerably. He suggested that this may be the result of a neurological reflex which narrows the tracheobronchial tree.

He then experimentally produced nasal obstruction in dogs, confirmed his human findings and found the reflex was reversible with removal of the nasal obstruction.

Fifty-four patients were then studied. Their nasal breathing capacity was placed on a grading 0 - 6. Nil represented a perfect nose with a straight septum and which was never blocked. Six represented a totally bilaterally and constantly blocked nose with gross septal deviations into both nostrils. Preoperatively, he performed ventilatory function studies, functional residual capacity, pulmonary compliance and resistance measurements. Following relief of the nasal obstruction, an improvement was noted in the pulmonary airway and tissue resistance in those patients with a previously high grading of nasal obstruction.

He, therefore, felt that nasal obstruction may well play a part in the early onset of chronic lung disease (Ogura 1964, 1966, 1977, Ogura and Harvey 1971, Ogura et al 1968a, b, Ohnishi et al 1972). The presence of increased mucous secretion as a result of a deviated nasal septum is explained by Gray (1967). The nostril which is the least patent has a higher speed of flow of air through the posterior choana. The Bernoulli effect diminishes the pressure which in turn leads to outpouring of mucus and a consequent post-nasal drip.

Ginzel and Illum (1980) found that in patients with septal deviations, the rate of nasal clearance of mucus was significantly lower before than after operative relief of the obstruction. McNicoll and Scanlon (1979) however, theorise that the increased airflow in the wider nostril dries out the secretions particularly at the lower end of the eustachian tube. The resultant thicker mucus blocks the tube which in turn prevents adequate inflation of the middle ear. Their conclusion is based on evidence from a series of divers with deviated septums who could not adequately "clear" their ears while at depth. Following a submucous resection, this problem was rectified. The effect of a deviated septum on eustachian tube physiology was previously highlighted by Gray (1967). He described an increased incidence of middle ear secretions in those patients with a deviated septum. The neurological connections between the nose and the cardiorespiratory organs via the common parasympathetic and sympathetic origins in the central nervous system are well documented (Mitchell 1954) (Cottle 1968, 1970, 1980). This would explain not only the aforementioned findings of Ogura but would also account for the association of nasal septal deviation and cardiopathies found by Giannoni (1967) and the high incidence of nasal septal deviations noted in patients admitted to a coronary care unit with an electrocardiographically proven myocardial infarction (Heinberg and Kern 1974).

This clinical association of cardiac problems linked to nasal obstruction is of fairly recent discovery and still requires statistical proof before wide acceptance. A nasal septal deviation is such a common condition, particularly in the age group most likely to suffer from cardiorespiratory problems, that one must view these so-called clinical associations with a degree of suspicion.

Cvetnic et al (1976, 1978, 1980) in a series of papers, describe the systemic effects of packing a nose. There is a disordered gaseous exchange in the blood and an increased incidence of cardiac-like symptoms such as chest pains and breathlessness. These changes are reversible with removal of the packing. Podoshin et al (1974) showed a diminished lung capacity with spirometer readings when the nose was packed which again was reversible when the pack was removed. All these authors show impressive numbers of patients with diminished arterial oxygen levels and elevated carbon dioxide levels and impaired ventilatory capacity with either obstructed noses or packed noses for epistaxis. The results from these series before and after packing or while the nose is obstructed and after the obstruction has been removed surgically, are very close.

It is well known that the taking of arterial blood may be painful and the cry of pain or a short breath holding episode may account for the degree of discrepancy in these figures. There have, however, been so many authors writing on this subject for such a long time one is inclined to believe the theory is, at least in part, valid despite the lack of good statistical verification.

A markedly deviated septum was found to cause impaired olfactory function in a few patients in a series whereby the authors sought to reassure that septal operations do not damage the olfactory organ. Following correction of the septal deflection, the sense of smell returned (Goldwyn and Shore 1968). The link between headaches and the deviated septum is well known (Comans 1962, Pellanda 1966, Baker 1966). Gray (1967) again explains that this is caused by the Bernoulli effect. The lax mucosa over the lateral wall of the nose near the deviation is sucked out and becomes oedemotous in response to the increased speed of inspired air and the consequent decreased pressure. The oedema blocks off the middle meatus thereby giving rise to vacuum headaches of the maxillary, anterior, ethmoidal and frontal sinuses. This explanation is only theory.

There is no doubt, however, that the operative correction of a septal deviation does relieve headaches in a number of patients. Whether the Bernoulli effect is the influencing factor in the causation of vacuum headaches or in the aforementioned increased production of nasal secretions is debatable.

THE NORMAL NOSE. Anatomy.

The anatomy of the nasal skeleton is well known. The nose is a three-walled pyramid which on the fronto-caudal side opens into the nostrils which are separated by the columella. The skeleton of the two lateral walls is formed from the caudal side by the lateral wings of the alar cartilages, the upper lateral cartilages and the nasal bones. In the median line, the pyramid is divided into two compartments by the medial alae of the alar cartilages, the cartilaginous septum and dorsally the vomer and perpendicular plate of the ethmoid. The upper lateral cartilages are directly continuous with the cranial third of the septum whereas the caudal two-thirds have only a fibrous tissue connection with the remaining portions of the upper and lower cartilages. The upper lateral cartilages are overlapped cranially by the nasal bones. This design means that a fracture of the lower portion of a nasal bone does not fall in but is held in position by the cartilage. The cephalic end of the upper lateral cartilage is overlapped by the lower lateral cartilage. The intercartilaginous incision used in the operation of rhinoplasty divides this attachment.

The membranous septum separates the medial crura of the lower lateral cartilages from the nasal septum and allows displacement of the columella over the caudal edge of the cartilaginous septum. The factor that determines the shape and phenotype of the human nose, depending on the race, is the base of the nose and the area of the caudal septum at the anterior nasal spine. Comparative anatomical studies point to the existence of fundamental differences in this area between the various human races.

The anterior nasal spine is less prominent in the Negroid and Asiatic races compared to the Caucasian. In the latter, the maxilla and the nasal spine have advanced further rostrally, thereby making the nasal spine a prominent bony landmark. (Walter 1969).

Embryological development of the nasal septal cartilage results from an extension of the cartilage of the cranial base. The bony septum is formed from several centres of ossification formed throughout early life. This information is based on the appearance of 18 septums of children aged 0-10 years immediately after death. (Schultz and Eckermeier 1976). The vomer begins to ossify at the second month after birth. Two ossification centres arise posteriorly in the floor of the nasal fossa and develop anteriorly and superiorly in two distinct bony plates which later unite leaving a groove along the ventral border to receive the quadrilateral cartilage. The perpendicular plate of the ethmoid develops enchondrally at a much slower rate and is not complete until the sixteenth year. At birth, the maxilla is united to the premaxilla but the septum is mainly cartilaginous with the exception of the vomer. This, therefore, must be borne in mind with regard to parturition which may cause moulding of this cartilaginous septum (vide infra). Pressure of growing cartilage may push down one lip of the vomerine groove and the cartilage partially dislocates off the groove. (Salinger 1952).

At birth, the connection between the cartilaginous septum and vomer and the anterior nasal spine is a small loose layer of connective tissue in which the fibres course in a figure of eight fashion. This gives the caudal end of the septum a certain degree of mobility. (Hinderer 1963).

The endochondral ossification zone of the rostrum sphenoidale which appears very active in the neonate, regreses considerably thereafter. The perpendicular plate of the ethmoid forms from multiple ossification centres in the dorso-cranial part of the neo-natal septum. The bony septum is initially a fast growing part of the neo-natal septum which is separated from the facial bones by cartilage. It later becomes united with the lateral processes of the cribiform plate. With the union of the bony elements of the septum at the sixteenth year, the facial and cranial bone growth of the posterior fixed suture system ceases and the facial sutures behind the maxilla are no longer sites of growth (Scott 1953).

After the age of six years, the speed of growth of the septum slows considerably. The speed of growth of the skull is high immediately after birth but slows to a minimum before puberty. After that, the adolescent growth spurt occurs which is followed by a gradual decrease of growth up to the adult stage. The facial skeleton continues to grow for a longer period than the cranial vault (Bjork 1955).

The important sites of growth for the maxillary complex are in order.

1. Fronto-maxillary suture.
2. Zygomatico-maxillary suture.
3. Zygomatico-temporal suture.
4. Pterygopalatine suture.

(Sicher and De Brul 1975).

The smaller paired nasal bones comprise the upper portion of the abbreviated snout. The nasal bones and the maxillary part of the lateral walls grow in the same direction i.e. anteriorly. The nasal bones also enlarge laterally, but to a lesser extent. The cutaneous side of each nasal bone faces both anteriorly and laterally and the periostial surface is correspondingly depository in nature. The inner mucosal surfaces of the nasal bones are resorptive. This growth combination seems to move the roof of the nose forward to expand it laterally and to slightly widen the nasal bridge. The nose also elongates as the face grows. (Enlow 1968).

In their upper part, the nasal bones are extremely thick and heavy and therefore very resistant to fracture but in the lower part as they approach the pyriform aperture i.e. the bony opening leading to the external nose, the nasal bones become very thin and are easily traumatised. For this reason, some nasal fractures may involve only the lower part of the nasal bones.

The importance of the growth of the nasal septum has been explained by Scott (1953). He suggests the septal cartilage is the site of the primary expansile growth force in the development of the facial skeleton in the antero-posterior and vertical directions (Scott 1956, 1957, 1958, 1959, 1963).

Experimental evidence for this theory is naturally lacking in humans but has been well documented in animals. For the treatment of nasal disease in humans, it is essential to identify the site of fastest growth of the septum and the most important area of the septum monitoring mid facial growth.

Trauma to either area in a young child could well have disasterous consequences. It was this very worry that prevented many surgeons of the early Twentieth Century from performing septal surgery on children. If the fast growing area was damaged, either the septum may not develop properly or undirected growth could lead to late onset deformity. Damage to those areas important for mid-facial development may lead to under-development of the middle third of the face and its attendant problems.

The growing ten day old rat was the experimental animal used by Searls and Kinser (1972). They injected one micocurie per gram of body weight of tritiated thymidine intraperitoneally and sacrificed their animals at various times following this. Tritiated thymidine is incorporated into the fast dividing cells of the growing septum. The septums were analysed with radioautographic studies to highlight those areas of high proliferative activity. The zone of greatest activity was in the sphenoid tail and zone of next highest activity was immediately anterior to the septoethmoidal junction. The third most active part was the centre of the septum. The other regions have a low proliferative activity. The authors, however, underlined that chondrocyte proliferative activity in the centre of the septum may vary from species to species.

Again using tritiated thymidine, Long et al (1968) investigated chondrocyte proliferation in a growing cartilaginous septum. The animals used were three week old Dutch rabbits. Following an intraperitonal injection of 258mc of tritiated thymidine, the animals were sacrificed one hour later.

The areas of most active proliferation of the cellular component were mainly the antero-inferior and the posterior zones of the cartilaginous septum.

The next step was to remove or damage various areas of the septum in a growing animal to see the effect on middle third facial development. A multiplicity of authors report the results of their work on this subject but unfortunately, no clear picture emerges.

Sarnat and Wexler studied the effect of damage to or removal of parts of the cartilaginous septum on the growth of the rabbit snout. This animal was chosen because the posterior cartilaginous septum sits on the vomer in an identical fashion to the human. In their first experiment, twenty-four rabbits of between 29-48 days old were used. In some, varying degrees of the septovomeral joint were removed, in others, the caudal portion of the cartilaginous nasal septum, vomer or maxillary process of the premaxilla were removed.

The survival times were 7-118 days. They found in all animals, severe deformities of facial growth with foreshortening of the snout and downward angulation of the nasal bones. They concluded the septovomeral region was the most important area for growth. Subsequent experiments where linear segments of the central area of the cartilaginous septum were removed, produced decreased development of the middle third o. the face. The experiment was repeated in adult rabbits where no external change was found in the external snout. Attention was then turned to experimental dislocation of the cartilaginous septum. The rabbit has a very straight septum normally which is 90% surrounded by bone.

Resection of cartilage or dislocation of the septum is, therefore, a very artificial occurrence in the rabbit. Seventeen rabbits of 5-7 weeks of age were used. Ten had their septums dislocated and seven were used as controls. There was no effect on growth of either the snout or the middle third of the face, sixteen weeks later at sacrifice. There was a marked tendency for the dislocation to spontaneously return to the original position. (Sarnat and Wexler 1966, 1967a, 1967b, 1968, Wexler 1971, Sarnat 1976, Wexler & Sarnat 1961, 1965).

Using the rat as an experimental model Ohyama (1965) performed what amounted to a routine submucous resection on 25 growing rats. In all of these, the nasal, frontal, premaxillary and maxillary bones were found to be shorter particularly in the antero-posterior direction, than in the controls. Growth of the upper part of the face was also inhibited.

Nordgaard and Kvinnsland (1979) Kvinnsland (1974) repeated this work on rats. They agreed with Ohyama and found the growth retardation of the snout most marked if at least 50% of the septum was resected. The total viscero-cranium length was, however, unaffected by total extirpation of the nasal septum. This latter finding presumably mis-led Moss et al (1968) who, again with total removal of the nasal septum in growing rats by electrocoagulation, could only produce collapse of the nasal dorsum. They felt this splanchno-cranial growth was normal.

Hartshorn (1970) produced a dramatic failure of snout and middle third development of the face with total removal of the septum and overlying mucoperichondrium in beagle pups. Bernstein (1973), however, felt that Hartshorn's experiments were unreasonably destructive as they included the mucoperichondrium. He believed that this latter structure could well hold the key to cartilage regeneration. He, therefore, repeated the experiments on 4-6 week old beagle pups but he left the mucoperichondrium as intact as possible.

Using many control animals and "sham" control animals where only the initial incision was made, his findings are considerably more accurate and more substantive than those of Hartshorn. Various parts of the cartilaginous septum were removed; dorsal, ventral, anterior, posterior and the whole of the septum. In other animals, autografts were inserted. In no animals did under-development of the face or snout take place.

In those areas of cartilage removal, new cartilage grew or with cartilage absorption, fibrous tissue formed in its place. All the autografts survived and grew with the rest of the septum. Four of the surgical controls had almost complete resorption of cartilage which was thought to be caused by haematoma formation.

Stenstrom and Thilander (1970, 1972) chose the guinea pig as their experimental models. Their findings were that no significant skeletal changes took place in the growing guinea pig face unless more than the anterior two-thirds of the nasal septum were removed. They suggested that this resulted from decreased snout stability because of loss of septal support rather than removal of a growing area of the septum.

Absolutely no skeletal changes occurred with extirpation of the vomer, extirpation of the nasal spine and adjacent part of the septal cartilage, the dorsal septal cartilage or the perpendicular plate of the ethmoid with or without adjacent septal cartilage. Undramatic skeletal changes occurred with extirpation of the septal cartilage anterior to the nasal frontal suture and some changes resulted from the removal of the perpendicular plate of the ethmoid and all the septal cartilage. They then suggested that perhaps remarkably fast cartilage regeneration in the growing animal might explain the absence of diminished middle third development but this could not be substantiated in further experiments. A ventral piece of septal cartilage in front of the perpendicular plate of the ethmoid was removed in some animals, in others the resection also included the perpendicular plate of the ethmoid. The animals were sacrificed from three weeks to six months and the effects remained open.

In summary, the authors could find no evidence of a primary growth centre in the septum of the growing guinea pig. A criticism, however, of all this work was made by Verwoerd et al (1979a, b and c) in that all the authors quoted had no detailed information on the normal development of the facial skull of the experimental animals during the experimental period. Verwoerd and co-authors previously determined that in a quantative study of the post natal growth of the rabbit's skull, the facial skull grows more in size and grows outward over a longer period than the neurocranium. The form of the growing neurocranium remains generally unchanged while the facial skeleton lengthens by the predominant growth in a ventral direction (Urbanus et al 1977). They used four week old rabbits as an experimental model.

Apart from control animals, they removed varying parts of the septum and overlying mucoperichondrium in the other animals; the cranio-dorsal part, the cranio-central part, the cranio-ventral part, the dorsal third, the central third and the ventral third. Sixty-three parameters were used for morphological analysis of the skulls. Twenty weeks after surgery, the animals were sacrificed. In all the animals where cartilage had been removed, there appeared a collapse of the dorsum of the nose. In the animals with a ventral resection, the nose tip became rounded. Most of the animals had shorter nasal bones than would otherwise have been expected. If the longitudial continuity of the septal cartilage was interrupted, there was under-development of the maxilla but this did not prevent growth of the nose or the middle third of the face entirely.

The authors thus concluded that if there is septal cartilage discontinuity, the physiological forward development of the maxilla, which normally occurs between four and twenty-four weeks in the rabbit, does not take place. If this septal continuity is interrupted, the post natal increase in the size of the nose and maxilla nearly equals that of the neurocranium and the skull grows proportionately. There will be no change from the "baby-face" to the "adult-face" which results from the extra growth of the facial skeleton.

The most recent paper on this subject (Evans and Brain 1981) confirms the growth retardation of the rabbit snout when various parts of the cartilaginous septum are removed. Nasal osteotomies did not affect the subsequent growth of the nose.

The earlier animal experiments quoted above suggested that trauma to the cartilaginous septum did not damage the "growth centres" of the septum and the middle third of the face but subsequent experiments did not substantiate this.

The surrounding controversy is explained by Verwoerd et al (1979) who demonstrated the lack of adult facial maturation as a result of cartilaginous septal damage in rabbits. These papers appear to be the most authoritative on the subject.

The experimental animal used may be of great importance. Septal damage to dogs and guinea pigs did not retard subsequent nasal growth but this did occur in rats and rabbits.

In all of these experiments, attention is drawn to the cartilaginous septum whereas Scott (1953) emphasises the importance of the region of the bony septum as a fast growing area which may influence facial and cranial bone growth in humans.

SEPTAL SURGERY IN CHILDREN AND THE EFFECT ON NASAL GROWTH.

The place of septal surgery in children is, of course, contentious. The possibility of upset in subsequent nasal and middle third facial development was appreciated by the pioneers of septal surgery and generally few septal operations were performed on children.

Indeed, the series of cases with congenital absence or early acquired absence of the cartilaginous septum from infection or operation described by Kemble (1973) seems to support the diffidence felt by those early operators on the nasal septum of children. All eight of Kemble's cases had under-developed maxillas by adulthood.

Metzenbaum described a more conservative technique than the classic submucous resection, however, whereby an anterior dislocation of the septum was replaced to its normal position as part of a compound flap (Metzenbaum 1929). This, therefore, did not involve the removal of large areas of cartilaginous septum, thereby hopefully retaining the growth centres for thenose and middle third of the face.

The good results from limited septal surgery on children can be testified to by a multiplicity of authors. Salinger (1941, 1944) feels a number of childhood septal deformities are post traumatic. Any dislocation of the septum from the vomerine groove is easily corrected. Other septal deviations should be treated with a conservative operation retaining as much cartilage as possible while creating a good airway. The commonly held view is that a careful septal operation in children retaining as much cartilage as possible will have no deliterious effect on subsequent nasal or facial development but to leave the child with a blocked nose due to a deviated septum has a more damaging effect on respiration, subsequent nose growth and the patient's psyche (Cottle 1951, Pont 1961, Fischer 1962, Jennes 1964, Huizing 1979).

Reddy (1968), in a Hunterian lecture, goes further and states that a classic submucous resection may be indicated in children. He feels there is no need to preserve the septum and there is no justification for leaving a child with nasal obstruction.

Pirsig has developed a particular interest in nasal trauma in children. He has not found any arrest of nasal growth in children following a septoplasty and in some cases, osteotomies. His histological findings from biopsies of septal cartilage suggest that cartilage regeneration does occur at the borders of areas of resected cartilage. The 261 cases he studied showed this growth was so undirected and excessive that in a small proportion of his cases, a new symtomatic septal deviation was created in time. The cartilage regenerative potential emanates from the mucoperichondrium, hence the importance of preservation of the structure. In children, this cartilage regenerates by both interstitial and appositional growth. Nasal trauma per se may result in loss, incomplete or complete regeneration of septal cartilage which may potentially affect the important growth centres. The defect is otherwise filled by fibrous tissue. (Pirsig and Lehmann 1975, Pirsig 1975, 1977, 1979).

Jacobs (1976) feels that if external deformation of the nose, which are subsequent on an internal septal deviation, are not corrected in childhood, the deformity will be exaggerated in adulthood and will be more resistant to treatment.

THE NASAL SEPTUM.

The nasal septum is an unpaired midline structure. The assumption is, therefore, that in the normal perfectly formed individual, the septum is straight. Septal deviations have long attracted the attention of physicians. The first mention of septal deflections seems to have been made by Quelmalz (1757). He suggested that the deviation may arise from the pressure of parturition or from habitual nose-picking. Since that time, innumerable works have been published on the aetiology and treatment of the deviated septum. There appeared to be a fashion of reporting the incidence of deviated septums in the latter part of the 19th Century. Sediak (1891) reviewed all the relevant literature of the time and tabulated his findings as follows:-

AUTHOR	DATE	PERCENTAGE DEVIATED	NUMBER OF CASES.
Zuckerkandl	1882	37.8	140 of 370 dry skulls
Delavan	1888	50	
Allen		68.9	58
Thrile		73.5	71 of 117
McKenzie	1884	76.9	1657 of 2152
Jarvis	1888	81	100
Lowenbers		86	
Sibonaesky	1890	95	925 of 974
McMann	1886	96.4	241 of 250
Sediak	1891	83.5	167 of 200

These figures, should, however, be viewed with caution. The results found by Zuckerkandl were from dry skulls only i.e. only the bony septum was examined. The other authors do not state whether a good appraisal of the bony septum could be achieved in their living subjects. Neither is it stated what constitutes a deviation or what is a "normal" nose. Almost every nose has at least some degree of deviation from the midline and the limits of normality are not stated in these series.

The great variation in the percentage findings of these authors reflects the problems involved in assessment of the normal nose. These figures are probably of little use.

Even the more modern investigative technique of rhinometry measures nasal airway resistance from the turbinates secretions as well as from the shape of the septum. These other factors make this investigation of limited value to assess septal deviations. An attempt to compensate for these latter variables is made by Wentges (1980) who shrinks the nasal lining by inserting a pledglet of cotton wool soaked in an adrenaline and lignocaine solution into the nose for a few minutes prior to the investigations. He suggests this allows the skeletal nasal airway to be measured without soft tissue interference.

Since Sediak's paper in 1891, interest appears to have centred more on the aetiology and treatment of the condition than on the incidence of septal deviation. Two more recent papers have, however, resurected the topic. Ali (1965) demonstrated a nil incidence of deviated septums under the age of one year old. This figure rose to 86% in those above the age of 25 years.

The finding of a steadily rising incidence of the deviated septum as age increases is of importance in this series compared with others because Ali screened all his 5,000 cases personally.

One must assume his criteria to distinguish normal from abnormal, remain the same throughout. He suggests the sharp increase in septal deformity between the ages of 10-25 years may be related with the growth phase of the individual and not to trauma. He has no evidence for this latter statement. The ease of diagnosis of a septal deviation also increases in the same age group. The accuracy of his figures are, therefore, open to doubt. He does state, however, that if the incidence of a deviated septum is 86% it can no longer be regarded as abnormal.

Vaino-mattila (1974) studied the septums of people in a small enclosed Finish Community. Fifty-two percent of the septums in the adult population had a straight septum but eleven percent had severe nasal obstruction due to a deviated septum.

Septal deviations have been variously described as "C" shape, "S" shape, spurs and fractures. The significance of each deformity has not been satisfactorily explained despite the attempt by Aubry et al (1966) and Harrison (1979) to relate spurs and fractures to trauma. Cottle (1950) divides nasal septal deformities into simple septal deviations, spur formations and ridges.

AETIOLOGY.

The aetiology of a deviated septum remains obscure although evidence is accumulating that trauma is an important factor. In the study of the septums of new born babies, Soboczynski (1970) found deviations in twenty-eight per cent. Some babies born by Caesarian Section had deviated septums but these were in the minority. He found a greatly increased incidence in those babies who had had some obstetrical procedure e.g. forceps deliveries and a smaller but significant incidence in those babies born "per via natura". Soboczynski feels that the pressures during natural childbirth imposed by the birth canal may contribute to the causation of a septal deviation but it is not the only cause.

The physicians of the late Nineteenth Century seem to rather overlook labour as a cause of a septal deviation principally because Zuckerkandl (1882) decreed that no persons of less than seven years of age could possess a deviated septum.

This idea did not meet with overall approval however. Spicer (1890) felt that neonatal trauma could lead to a septal deviation. One wonders how thorough any of the Authors mentioned by Sediak (1891) were, as none of them appeared to put emphasis on the diagnosis of a septal deviation in the neonate.

Gray (1965a) and later Pease (1969) felt that mere inspection of the neonate nose only revealed anterior septal deviations. Gray designed a polythene strut of a measured size which he inserted into the nose of a newly born infant.

The rod should pass evenly through both nostrils but a posteriorly placed deviation prevents the rod entering the posterior choana.

Quante et al (1976) examined the noses of 972 patients aged from 3 to 82 years of age. They compared the appearance of the nose both internally and externally with the "severity" of the birth.

None of the 49 babies born by caesarean section had nasal obstruction but 17% of the 923 babies born naturally had a stuffy nose. Sixty percent of the 923 babies had an external deviated nose and over 80% had some form of septal deformity. Those babies born by caesarean section had an extremely low incidence of septal abnormality. Assymmetry of the skull appeared to correlate well with a higher incidence of nasal abnormality compared with the normal skulls.

They further proceed to suggest that the rotatory direction of the infants head as it passes down the birth canal and through the pelvis in the first and second stages of labour determines the direction of the deformation of the nose. This assumes the presentation is vertex and not a breech. As a rule in white races, the occipito-nasal diameter and not the occipito mental diameter is the greatest in the new-born infants head (Ersner 1944, Cottle 1955).

Jazbi (1947) makes the point that birth trauma may produce flattening of the nose which corrects itself spontaneously. He feels that if a septal dislocation has occurred during parturition, the cartilage should be replaced in the vomerine groove by an otolaryngologist within the first two-three days of life. This advice is underlined by Klaff (1963) and Kirchner (1955).

Many authors have been involved in the identification of the problem of nasal trauma during birth. The following table summarises their findings:-

AUTHOR.	NUMBER STUDIED.	SEPTUMS DISLOCATED.
Birke	542	4% severe
Ersner	25	8%
Boyden	700	12%
Steiner	100	6%
Pease	956	2% severe
Montserrat	215	21% slight 4-8% septal dislocation 14% pyramid deformation
Jeppeson	9,707	1.5%
Gray	2,000	2-3% anterior dislocation 17% pronounced septal deformity
Quante	972	20%
Cottle		6.7%
Silverman and Lebow	1,200	1%
Soboczynski		28%

The whole picture is, therefore, still confused and under debate. Jeppeson and Winfield (1972) add further to the controversy by describing two infants born by caesarean section before initiation of labour who had dislocated septums.

They feel that uterine pressure rather than the passage through the birth canal may account for up to two-thirds of neonatal septal deformities. This theory is supported by the work of Ruano-Gil et al (1980) who found two foetuses out of 50(4%) with septal deformities. In both of the septums, deformities were present in the perpendicular plate of the ethmoid in the part which undergoes early ossification.

No single hypothesis appears to explain all the above findings and probably there are many combinations of injury, growth and arrest of development in different areas of the middle third of the face which lead to subsequent deformity (Stevens 1970).

Stoksted et al (1979) add another possibility to the causation of neonatal septal trauma namely moulding of the head. One of the most experienced workers in this field, Gray, agrees with this point of view and goes on to further suggest this is one of the main causes of septal deformities. He identifies four types of cranial deformity at birth due to variable amounts of pressure during pregnancy or parturition:-

1. Cranial vault moulding.
2. Mandibular malalignment on the maxillary margin.
3. Anterior external nasal deformity.
4. Facial deformity with maxillary compression and internal nasal deformity.

The latter two types of deformity result in a septal deviation. In type three, a fracture of the nasal bones may also be present.

Gray suggests that this, essentially cartilaginous type of deformity may dislocate the septum from the maxillary crest. Whether or not this is the case, subsequent growth exaggerates the deformity. Unequal growth of the vomer up the side of the cartilaginous septum results with decreased ossification of the ipsilateral side of the perpendicular plate of the ethmoid. Eventually, a compensatory hypertrophy of the inferior turbinate on the concave side will occur. This type of septal deviation may occur at any age as a response to trauma of the appropriate force and in the appropriate directions. Parturition can produce a suitable type of trauma to create this deformity. Type 4 septal deformity or the combined cartilaginous bony type probably results from compression of the maxilla bones during parturition. This produces kinking or mal-alignment of the septal components. He theorises that if there is little difference in the pressures on each side of the face, the roof of the palate rises symmetrically compressing the septum against the firm base of the skull. This causes irregular distortion or even fracture of the septum and splaying out of the vomer-cartilage junction. Because there is no bending of the vomer cartilage junction (and thus no loss in the opposing growth controlling forces of the bone and cartilage) the deformity does not increase with age. If, however, the pressure is unequal, the palate is elevated on the side under highest pressure thereby tilting the vomer to the opposite side causing kinking of the vomer cartilage junction. There is compensatory enlargement of the ethmoids and turbinates on the concave side of the septum. As there is loss of the opposing controlling forces at the vomer cartilage junction, the deformity increases with age. The presence of the combined septal deformity in infants may be demonstrated by the passage of polythene nasal testing struts, 6mm wide by 2mm thick which were designed by Gray to the back of the nose.

The incidence of septal deformities as found by Gray using this method from 2,380 births is tabulated below:-

Type of Delivery	Number	Straight Septum	Bilateral Deviated Septum	Unilateral Deviated Septum	External Deviation
Spontaneous Vaginal delivery	2094	43%	26%	31%	4%
Elective Caesarean Section	106	48%	25%	27%	Nil
Non-elective Caesarean Section	113	40%	34%	26%	Nil
Persistent Occipito Posterior position	67	26%	37%	37%	13%
Total:	2830	42%	27%	31%	4%

Gray cannot, therefore, correlate birth trauma to a combined bony cartilaginous septal deviation but parturition would appear to be of significance in the creation of an externally deviated nose. His studies on human skulls correlates with his clinical findings. He studied 2,112 adult skulls of five different ethnic types and 918 mammals of varying degrees of evolution.

He found septal deformities to be rare in lower mammals but present in an incidence of up to 37% in higher apes. He identified septal deformity as a part of a facial deformity in most humans. In particular, he found that if the anterior nasal fossa floors were uneven, the posterior septum was never straight. He could not, however, correlate the anterior deviation abnormaility with uneven nasal fossa floors. Of the 2,112 adult skulls he studied, only 21% had a straight septum. The Unilateral Septal Deviation was present in 42% and 37% were Bilaterally deviated,Gray (1965a, b, 1969, 1972, 1974, 1977, 1978).

Much of this work has been further confirmed by Pirsig (1979) who divided traumatic deformations in the nose of the new born into (a) flat noses which comprise 30-60% of all deliveries, (b) anterior septal deformities 2-23% and (c) combined septal deformity which he believes is present in up to 50% of normal deliveries.

Previous authors have suggested that a septal deviation is a reflection of natural facial assymmetry but with little evidence. Facial assymmetry may also result from skull deformation in utero or during birth (Cook 1980).

Coolidge and others also explained the presence of a deviation or a spur as the result of the natural assymmetry of the skull acting on the thin osseo-cartilaginous plate of the septum which tried to grow forward during development but was held firmly by a bony frame. (Coolidge 1904, Woakes and Walsham 1890, Zorzoli 1950).

Takahashi (1977) believes he can trace the evolution of the deviated septum to the time of Neanderthal man. He suggests the vomerine process which becomes progressively smaller further up the evolutionary tree, is in some way related to nasal septal deviation. He likewise strives to relate the presence of an acute angle between the nasal septum and the skull base at the sella turcica as is found in man but not in low primates to a deviated nasal septum. His conclusions are purely conjecture and have no scientific basis.

Some authors have found a male predominance of septal deviations (Sediak 1891), whereas others a racial difference with the European racial type in the majority. (Gray 1978, Zuckerkandl 1882). Other possible causes of a deviated septum include nose-picking (Quelmalz 1757), thumb sucking (Hein 1972) and natural selection of genes (Post 1969).

Pejic (1949) studied five families for three or four generations and came to the conclusion that hereditary is a causal factor. The deviated septum is such a common condition that in the absence of controls, Pejic's conclusions are unwarranted.

Many authors feel that an un-diagnosed or inadequately treated nasal fracture in early childhood contributes to the formation of a deviated septum in later years. The initial injuries are often forgotten and thus a diagnosis of "idiopathic" deviated nasal septum is made. Pirsig (1975, 1979) has performed histological studies on septums from children who had trauma either surgical or non-surgical many years previously. He found undirected regrowth of the cartilaginous septum which, in a few cases, was sufficient to impair nasal breathing. In particular, the diagnosis of a traumatised nasal septum may be difficult. A greenstick fracture may be easily overlooked in a cursory examination. Subsequent growth may cause this particular injury to worsen rather than improve in adulthood (Drumheller 1971).

Soft tissue injury likewise at an early age may interfere with septal development leading to curvature (Carter 1930) and the presence of a septal haematoma may lead to resorption of the cartilage of the septum without necessarily superadded infection (Firestone 1948).

An early evaluation of the extent of injury is, therefore, indicated (Facer 1974) and in some children, a general anaesthetic may be deemed necessary to ensure a correct diagnosis (Hadley 1969). Prevention of a deviated septum in a child following trauma may necessitate operative intervention. (Olsen et al 1980).

By the time adulthood is reached, the majority of people have a deviated septum. It cannot, therefore, be stated that a deviated septum in the human is abnormal.

A septum may only be deemed abnormal if the deviation is sufficient to cause symptoms. Many other factors influence the nasal airway.

These include the width of the nose, the size and dilatory capacity of all the turbinates and the presence of other pathology in the nose e.g. allergy, rhinorrhea and polyps etc. There appears to be strong evidence that trauma is a major factor in the aetiology of a septal deviation. No other theory has been proven or has gained worldwide acceptance.

TRAUMA TO THE MIDDLE THIRD OF THE FACE.

The middle third of the face is that area principally bounded above by the supraorbital margins of the frontal bone and below by the incisal edges and occlusal surfaces of the maxillary teeth. The anterior limits are self evident and the posterior limits are conveniently defined by the free edges of the pterygoid laminae.

Trauma to this area may take many forms, blunt or sharp, slight or forceful or may be directed from an anterior or lateral direction. Any classification is only of use if it is of either practical use or of academic use c.f. the Internationally Accepted T.M.N. classification for the staging of cancer. Many authors describe classifications of nasal fractures which bear little heed to either academic or practicality. Similarly, a lot of these classifications may vary considerably which would indicate a general lack of understanding of the underlying mechanics involved in nasal trauma. Only one author (Harrison 1979) has attempted to re-create nasal bone fractures and study the results closely; all other authors depend on clinical judgement to separate different kinds of nasal fractures.

Stranc and Robertson (1979) describe the lateral force fracture and the frontal impact fracture. This latter, less common fracture, the authors feel, may be sub-divided into three levels depending on the force involved. Plane 1 injuries do not extend beyond a line joining the lower end of the nasal bones to the anterior nasal spine.

Plane 2 injuries are limited to the external nose and do not transgress the orbital rims. Plane 3 injuries are serious as they involve orbital and possibly intracranial structures. The Plane 1 injury is frequently under-diagnosed due to minimal clinical and radiological signs. The force is spent primarily on the septal cartilage. There may be comminution of the lower end of the nasal bones and fracture of the anterior nasal spine. This injury may cause a fracture of the cartilaginous septum which runs from the anterior maxillary spine to the anterior end of the nasal bones. This is known as the fracture of Chevallet (Aubry et al 1966).

Force directed onto the nasal bones themselves may produce a subperiosteal haematoma along with no underlying fracture of the bone. A suitably directed blow can fracture the fragile inferior edge of the nasal bone (Moore and Harris 1940). It is accepted these latter injuries do not require early surgical treatment.

In 80% of 190 cases of a fractured nose, Kazanjian and Converse (1959) found that the nasal bones break horizontally along the ill-defined line where they change from thick to thin.

Gollum (1963) presents a useful, although incomplete, classification of nasal fractures. He describes the following:-

1. a linear fracture with no displacement.
2. a greenstick fracture of either the bony arch or the septum.
3. a simple depressed fracture of one nasal bone.
4. a lateral displacement of the bony arch as a unit with a fracture of the arch. The septum is commonly involved.

5. a depression of the dorsum with crumpling of the septum.
6. a fracture or displacement of the septum; either cartilage or bone.
7. a detachment of the upper lateral cartilage from its attachment to the under surface of the caudal end of the nasal bone.

Aubry et al (1966), however, with a similar classification related to the angle of force described the cartilaginous fractures in more detail. The commonest is a fracture parallel with the maxillary crest. This results from anteroposterior force and produces the fracture dislocation of Jarjavay. The next most common cartilaginous fracture is named after Chevallet. This fracture runs from the maxillary crest anteriorly to the nasal bone superiorly. They believe this results from inferosuperior trauma. The anonymous least common fracture runs parallel with the caudal end of the septum. They also introduced the concept that in the adult, the nasal bones form a solid block. This, they believe, means both nasal bones fracture at the same time if the force is adequate to cause displacement of the nose. In this latter fracture and in a lateral comminution of the pyramid, the septum is also fractured.

According to Aubry et al, the unilateral nasal bone fracture and the "open-book" type of nasal fracture are only encountered in children. This latter concept is not widely accepted.

One of the most widely quoted nasal fracture classifications is that of Becker (1948). His descriptions are greenstick, linear, frontal, frontolateral and fracture from below. His information is derived from one hundred cases of a fractured nose but it is not a great help either in diagnosis or treatment.

Cox (1935) believes that a lateral deformity will result even from a straight-on blow. In contrast to the isolated nasal fractures, the more severe fractures of the face have been closely studied and the anatomicopathological features have been accurately documented.

The plane 3 type injury described by Stranc and Robertson involves greater force directed in an antero-posterior direction and results in damage to the maxillo-facial skeleton. The Le Fort I or Guerin fracture is essentially a low level separation of the upper jaw. The line of fracture commences above the anterior nasal spine and completely divides the septum at this level.

Fractures pass on either side from the inferlateral margins of the pyriform aperture, across the lateral and medial walls of the antrums below the level of the zygomatic buttress and the inferior turbinate bone, to the ptergoid plates just above the level of the maxillary tuberosities.

The Le Fort II or pyramidal fracture begins about half way from the free margins of the nasal bones towards the frontonasal suture. The septum is divided about midway between the nasal floor and the roof, fracturing the vertical plate of the ethmoid and the vomer. The fracture lines also pass, on both sides, across the frontal process of the maxilla anterior or sometimes through the bone of the lacrimal fosa towards the infra-orbital canal in the floor of the orbit. At this point, there is a divergence of the fracture line with one limb passing forwards over the inferior-orbital margin and inclining down wards through the area of the infra-orbital foramen to pass beneath the zygomatic buttress and across the ptergoid laminae a little higher than in the Le Fort I fracture.

The other limb passes posterolaterally towards the inferior orbital fissure and traverses the orbital floor. This latter line of fracture continues across the posterior wall of the antrum to join up with the former line of fracture in the region of the pterygo-maxillary fissure. In this way, a pyramidal block of bone is separated, corresponding approximately to the central middle third of the facial skeleton.

The Le Fort III fracture is a high level cranio-facial disjunction. It commences in the region of the fronto-nasal and fronto-maxillary sutures but passes on either side through the region of the fronto-lacrimal and fronto-ethmoid sutures along the medial wall of the orbit until the paper thin bone of the orbital plate of the ethmoid is replaced by the dense lesser wing of the sphenoid thus causing the path of the fracture to be deflected downwards to cross the base of the pterygoid laminae. This change in direction is fortunate since the optic framen is located within the lesser wing of the sphenoid bone and is thus protected by injury except in the case of exceptionally severe trauma or bizarre lines of fracture.

Supplementary lines of fracture occur laterally, passing from the fronto-zygomatic suture along the interface between the zygomatic bone and the greater wing of the sphenoid to the anterolateral limit of the inferior orbital fissure and also through the narrowest portion of the zygomatic arch. The whole of the facial skeleton below the level of the frontal bone and the sphenoid bone is thus detached. In both the Le Fort II and III and often in isolated naso-ethmoidal injuries, the cribiform plate is comminuted. This produces a communication between the anterior cranial fosa and the nasal cavity. The Le Fort lines of fracture are guidelines rather than dogma. In practice, combinations or variants may occur (Rowe 1975).

These variants of the Le Fort II type fracture have been variously described as a fracture of the ethmoids (Dawson & Fordyce 1953) a naso-orbital fracture (Converse & Smith 1963) and a naso-ethmoid fracture (Stranc 1970).

A pseudo hyperteleorism may result from the latter fracture owing to disruption of the attachment of the medial canthus, but the interpupillary distance remains the same. A true hyperteleorism where the interpupillary distance is increased, may occur if the medial wall of the orbit is disrupted in this fracture. (Montgomery 1979). Variations of this fracture have also been reported. Alonso (1970) reports a traumatic telescoping of the nasal bones into the base of the skull.

From the 3 plane type of classification of facial trauma as described by Stranc and Robertson, it is probable that minor trauma which produces cartilaginous septal damage is considerably more common than more major trauma which produces bony damage. Masing (1965) assesses he can relate 80% of his septal cases which require operation to the direct result of trauma. The concept of the diagnosis of a broken nose depending on a fractured nasal bone is thus erroneous and the full extent of the problem of nasal trauma is probably vastly underestimated in the clinical setting.

THE DIAGNOSIS OF A FRACTURED NOSE.

The diagnosis of a fractured nasal bone is obtained from the history of the event, a good clinical examination and the use of ancillary aids such as radiology. The assessment of the patient with a broken nose is, on occasion, difficult. Swelling and bruising may mask the bones and the patient may not have an accurate idea of his pre-traumatic nose shape. Even with light palpatation, the examiner may fail to feel a fracture if the overlying swelling is gross. Likewise after reduction, the shape of the nose is assessed on clinical grounds. Photographs of standardised views of the face and the nose are helpful in the assessment of pre-operative and post-operative patients but measurements of various distances are subject to large variations unless the photographs are absolutely standardised. This latter technique is called photogrammetry. (Farkas et al 1980). Obviously, the assessment of the nose from a non-standardised, non-clinical photograph is much less satisfactory as minor changes in the angle of the face or lighting may present quite a different appearance of the nose.

Cephalometry is a useful tool to measure various bony relationships in the skull but is used mainly for growth studies in the sagittal plane of the skull. Also the technology is extremely expensive and thus not widely available for everyday use to assess a broken nose. (Rabey 1968, 1971, 1978a, b, Letzer and Kronman 1967).

The new concept of Moire topography which provides a one-step contour line map of the face may well fill the gap in the diagnostic ancillary aids at present. A relatively simple aparatus is used with a grid and point source illumination with instant-processing film to produce immediate contour maps superimposed on the object image on the film. There is fine resolution of this system which can be quantatively analyzed by either a hand ruler or a caliper. Any deviation of the nose from the midline is highlighted. Obviously, the pre-operative and post-operative results may be compared not only visually but also quantatively. This system, which at the present is only used for major fractures is, however, very much in its infancy and still requires testing before wide acceptance. (Karlan & Cassisi 1979, Karlan 1979, Karlan & Skobel 1980).

Radiology has been the cornerstone in the diagnosis of a broken nose for many years. Doubt has, however, recently been cast on the accuracy of this method to diagnose a fractured nasal bone. Nasal bones are imprinted with the normal markings of neuro-vascular grooves which may, on occasion be mistaken for a fracture. (Samuel & Lloyd 1978). Lacey et al (1977) radiographed 50 dry skulls from the occipto-mental view. They could not distinguish between the suture lines or the vascular markings. Likewise, they did not feel this view would be of help in the diagnosis of a fracture. One hundred patients with nasal trauma were also studied. Only 45 had radiological evidence of a nasal fracture. Of these,41 were seen only in the lateral view, 2 were seen on the occipito-mental view and 2 were seen on both views. In fact, only 3 patients from this number were subsequently operated on to reduce their broken nose.

Lowenthal (1953) feels that X-rays are only helpful if the fracture line is obvious. He uses the postero-anterior view, a lateral view and an occlusal view. In this latter view, the film is held inside the mouth by the teeth and the beam is directed from above. This latter view is commended by Bernstein (1959). Maekawa (1968) uses the above views but also includes a Waters projection and a transoral projection which is midway between a Waters and axial projection.

A good radiograph may be of some help in establishing the diagnosis if the nasal outline is obliterated by swelling (Shultz 1970) but many authors do emphasise limitation of this investigation. (Gosserez 1956, Cox 1935, Becker 1948, McLemore 1952, Joseph 1975). Caparosa & Zavatsky (1957) even suggest that radiographs should only be made for medical-legal purposes and not necessarily for clinical help. Cohen (1923) goes even further to state that the diagnosis of a broken nose is easy and that to take radiographs is superfluous. In confirmation of this assertion, McArthur (1971) found that no dependance could be put on the investigation.

Fifty-three percent of his series of 160 patients with nasal trauma had radiological evidence of a fractured nasal bone. In 21%, the bone was radiologically depressed or displaced but three-quarters of these patients had clinically straight noses. He further proceeded to examine the cost effectiveness of this examination. A series of radiographs to diagnose a fractured nose costs about half that for an intravenous pyelogram and three-eights of that, a barium meal. He does, however, encourage the use of radiographs if there is a likelihood of extension of the fracture outwith the nose.

Most clinicians depend on their clinical judgement with vision and palpation of the nose to decide whether or not to manipulate the fracture. Schultz (1970) goes further to suggest that no matter what the clinician felt, if the nose was fractured on the X-ray the end result of the healing process would be poor unless the nose was manipulated.

A nasal fracture may be accompanied by a number of associated problems e.g. epistaxis, severe bruising, haematoma, lacerations, perforation of the septum or loss of septal height. (Drumheller 1970a, Roe 1898, Rubin 1966). There is no suggestion, however, that any of these signs may be used as an adjunct to aid the diagnosis.

The danger of a septal haematoma in a child's fractured nose is underlined by multiple authors (Fry 1969a, Mollinson 1938, Drumheller 1970a, b). This collection of blood between the cartilage and mucoperichondrium appears to be more common following nasal trauma in the child than in the adult. This may be due to the increased flexibility of the child's septum compared with the adult septum. (Moran 1977).

The consequences of an undrained haematoma may be resorption of the underlying cartilaginous septum with a consequent dorsal depression or a septal perforation. Alternatively, the haematoma may become infected to form an abscess which can deliver septic emboli through venous drainge channels to the cavernous sinuses causing a thrombosis and its associated high fatality rate.

Much attention has been drawn to the difficulty in diagnosis of a fractured nose in children (Moran 1977). Nasal fractures are accompanied by haematoma, ecchymosis and oedema. The child's nose and nasal bones are small. The possibility of the fracture being of the greenstick variety should always be borne in mind. Despite the use of ancillary aids, some fractures are not recognised and on occasion a general anaesthetic may be necessary to make the diagnosis. The danger of damage to the growth centre should be recognised but the main problem is a subsequent uneven disturbed growth of the nose following an undiagnosed fracture. (Kelly 1937, Kristensen 1952, Heinberg 1958, Hadley 1968, Goode & Spooner 1972, Drumheller 1970a, b, Willemot 1974).

Bull (1979) has some elegant photographs of identical adult twins one of whom suffered an untreated septal haematoma as a child. There is obvious under-development of the nose and also to a less noticeable extent there is midfacial hyoplasia.

THE TREATMENT OF NASAL BONE FRACTURES.

The timing of an operation on the broken nose is dependant on several factors. Ideally, the fracture should be reduced as soon after the trauma as possible but this clearly cannot always be the case owing to late patient self-referral. Nevertheless, many authors feel that an early reduction of the fracture ensures a better end result despite the presence of swelling which masks the true shape of the nasal bones. (Cohen 1923, White 1931, Gerrie 1938, David 1942, Jordan 1953, Seiferth 1954, King 1963, Masing 1975). On the other hand, the clinical impression gained once the swelling has subsided is thought to be more accurate by other equally eminent authors and manipulation at this stage will be more efficacious. (Kilner 1942, Roberts 1950, Aloin 1952, Joseph 1975, Fry 1978).

These latter authors do not feel that the fibrosis from the healing process which will have begun by the time of operation interferes with their manipulation of the bones into their original position. No authors, however, produce hard evidence for their beliefs and their advice is dependant on clinical impression.

The standard treatment of a nasal fracture is to manipulate the nose back into the middle of the face. This may be achieved solely by the pressure of fingers (Woodward 1935, Straith 1937a, b, Straith & Dekleine 1938) or by elevation of the fragments. For this latter method, some instrument, usually a form of forceps, is used. These are usually Asch's or Walsham's forceps.

One limb of the forceps is placed within one nostril, the other padded limb on the external nose. The bone is grasped and mobilised. It is probably better to fully mobilise the segment i.e. complete the fracture before final manipulation. An alternative is to insert some form of elevating instrument to guide a single depressed bony fragment back into place with the other hand. (Malbec and Quaife 1948, Walden 1951, Collins and Middleton 1952, Thompson 1966, Bickmore and Dayton 1966, Stell 1980).

Manipulation is performed by some surgeons immediately after injury when the nose is still numb from the injury. This procedure is usually limited to thumb pressure to restore the normal contours. Many authors, however, perform their operation using forceps under local anaesthesia without untoward problems. (Hayes and Vance 1969, Buck 1965, Roberts and Roberts 1952, Sletzer 1973). Conversely, the opposite view that a general anaesthetic is necessary for the operation to be performed properly is equally strongly held. (Straith 1937a, b, Watkins 1960).

The results of this operation are, like many other aspects of nasal trauma, the subject of controversy. Those authors who believe this operation is good and useful (White 1931, Watkins 1933, Winters 1967, Fry 1978) are balanced by those who feel the procedure renders poor results. (Woodward 1935, Harrison 1979, Pirsig 1981).

Mayell (1973) in a retrospective study of 107 cases after nasal manipulation found a failure rate of 35% demonstrated by lack of improvement in the shape of the nose. Fifty percent developed airway problems following manipulation.

Despite the belief by Fomon et al (1946) that the septum is a redundant safety factor in the arachitecture of the nose, the importance of the septum in more severe nasal trauma is recognised by many authors. Collins & Middleton (1952) suggest that only in a severely comminuted nasal fracture is the septum affected and the simple nasal bone fracture rarely involves the cartilage.

Winston (1974) and Wexler (1975) believe that the nasal bones unite in the line of the septum. Beekhuis (1980) likens the nasal pyramid to a tent, the septum being the tent-pole. If the nasal pyramid is moved laterally, the tent-pole either bends or breaks. If the septum is, therefore, not corrected at the same time as the nasal pyramid, the bones will be dragged out of alignment post operatively. "As the septum goes, so does the nose". These authors however, only recommend reconstruction if the septum has been obviously damaged by the trauma.

Reduction of the septal fracture may be attempted with septal forceps (Cohen 1923, Maliniac 1945, Mackenzie 1950, Woodward, 1935) which reputedly produces a good result. A more radical approach which is the accepted method of treatment today of a deviated nasal septum, is to perform either a submucous resection of the nasal septum or a septoplasty operation in conjunction with a nasal manipulation. The differences between these two operations are a subject in their own right but in essence, a submucous resection involves the removal of reasonably large areas of cartilaginous and to some extent, bony septum whether or not they are deformed.

The object is to allow the mucoperichondrial flaps to lie straight from the dorsum to the maxillary crest and vomer. A septoplasty operation involves the removal of much less cartilage but that which is retained is moulded from an abnormal shape to make the cartilaginous and bony septum straight. There are various advantages and disadvantages of either operation, but basically, the submucous resection was designed purely to ensure an adequate airway whereas the septoplasty operation was designed with the added requisite of cosmesis in mind.

Other modifications in the treatment of the acute nasal fracture include the completion of greenstick or partially fractured nasal bones. Collins (1954) recommends the vigorous use of forceps to achieve this but the resultant fracture will be uncontrolled and the fracture lines may run at random. For more control of the fracture line, several authors recommend the use osteotomies in a manner similar to that of the classic rhinoplasty. Via intercartilaginous and pyriform incisions, a chisel may be delivered into the fracture site and the osteotomies continued in the usual manner to fully mobilise both nasal bones individually. (Beekhuis 1970, 1980, Hinderer 1972, Jordan 1953a,b, Fomon 1936). This technique is, however, more commonly used in the surgical treatment of an old fracture when fibrosis has healed the break and the osteotomies reopen the fracture.

The precise alignment of the nasal bones at the site of lateral fracture can also be troublesome. Bull (1981) recommends the use of a small incision directly over the fracture site to allow direct vision while reducing the fragments accurately.

The whole concept of extending rhinoplasty techniques to the treatment of acute nasal fractures may be termed open reduction. Gollom (1954, 1955, 1963) lists the indications for open reduction as follows:-

1. Severe impaction.
2. Delayed reduction.
3. Fractured open septum with overiding segments.
4. A compound fracture.
5. To evacuate a septal haematoma.
6. Oedema interfering with accurate reduction.
7. A recent fracture associated with previous deformity.
8. Detachment of the upper lateral cartilages from the nasal bone.

Fomon et al (1952) assessed the relative merits of open and closed reduction i.e. simple manipulation. A closed reduction allows rapid coaptation of the bony fragments with a minimum of in-patient care. No special instruments or expertise in rhinoplasty techniques are required for a manipulation.

This method does not lend itself to an accurate assessment of the extent of the damage or of the structures involved. There is no guarantee of precise reduction and not infrequently, there is post-operative deformity and diminished nasal function. The authors recommend that manipulation should be restricted to simple fractures of the bony vault and is contra-indicated in extensive cartilaginous damage.

Open reduction, however, allows a more accurate inspection of the fracture to facilitate assessment of the extent of the damage and the structures involved. A more precise realignment of the bony fragments is possible and therefore, a better post operative result should be achieved. Fomon et al (1952) recommend this operation for all nasal fractures but it is a relatively more time consuming procedure, requires more in-patient care, needs special instruments and necessitates considerable training in rhinoplasty techniques.

No controlled trial has been performed comparing one technique with another and many of the opinions quoted previously are derived from clinical impression.

Harrison (1979) in an excellent paper, suggested the removal of a strip of bone and cartilage at their posterior interface on the septum and another strip of cartilage immediately above the maxillary crest to allow centralisation of the septum in a traumatised deviated nose. The results are assessed in terms of "good" and "perfect" and compare favourably with those who had only a manipulation. His various trials are, however, totally uncontrolled and are assessed solely by the author. The results he presents are so impressive that this form of treatment obviously required further investigation.

NASAL SPLINTS.

According to Fry (1966) an external splint following the reduction of a nasal fracture should fulfill three functions.

1. Maintain the bony arch in over correction.
2. Control the soft tissue swelling.
3. Protection against further trauma.

The use of external splints is extremely common. Vast numbers of papers have been written comparing the advantages and disadvantages of splints of various designs and materials. This probably underlines the uncertainty felt by clinicians regarding the usefulness of external splints. All the authors claim a high degree of success with the use of their particular splint but no controlled trials have been instituted and there is no statistical evidence for their claims. (Risdon 1931, Straith, 1937b, Cox 1935, Goldman 1950, Gerrie 1934, Negus 1942, Freeman 1970, Watkins 1933, 1969, Clark 1969).

The different materials used must be capable of being moulded to the shape of the reduced nose and to retain their shape in spite of swelling or movement of the nasal bones underneath. The presence of even a small degree of swelling of course, does not allow the splint to fulfill its functions. The Plaster of Paris splint as recommended by Fry (1966) and Mayell (1973) appears at least theoretically to be a good choice. This material, when wet and first applied, is easily moulded to the shape of the nose and it sets to a hard consistency. Its fixation is, however, difficult and it can be distorted by moderate postoperative bleeding.

The use of metals would not appear to be as suitable; the initial moulding of the splint to the nose may be inadequate due to the malleability of the metal. The splint itself, however, may be considerably stronger than a plaster splint. Salinger (1934) and White (1931) recommend the use of copper, Himmel (1949) uses tin. Dekleine's (1951) splint is made of aluminium and sheet lead is the material suggested by Downie (1893). Peariman (1940) and Singer (1971) merely state that metal would be a suitable material for a nasal splint.

Other compounds and mixtures used for a nasal splint include lead and modelling wax (Kilner 1942) orthoplast (Kean 1971) and dental impression compound (Gerrie 1938, Watkins 1960). The use of a lead and plaster of paris splint by Herbert (1947) attempts to gain the advantages of both materials for the splint. Clark (1969) emphasises the need for a forehead flange and a maxillary flange to the external splint of whatever material to avoid excessive strain on the nasal bones with a lateral blow.

Other means of stabilisation of nasal bones and in particular to hold up a depressed fracture of the nasal pyramid in the corrected position include the use of lead plates. These are placed externally over the bones. Stainless steel wires are passed through and through the fracture sites and the plates to hold the bones together. (Gejrot and Martensson 1960, Brown 1939, Annandale 1888).

Internal splinting of nasal fractures is less popular than the use of external splints. Perhaps this is a reflection of the cognizance of septal involvement in nasal fractures. The iodoform gauze internal splints or variations thereof are by far the most popular (Straith & Dekleine 1938, McLemore 1952, Becker 1948, Hurst 1960, Hersh 1945, Watson-Williams 1931). As with the external splint, a variety of other materials have also been used e.g. foam rubber (Roberts and Roberts 1952) and tampons made of melted parraffin wax (Volkov 1958). Patent nasal airways may be retained from the use of the polythene splints designed by Doyle et al (1977).

More extreme forms of stabilisation have filtered through mainly from maxillo-facial principles. The use of the forehead or the teeth as an anchorage to support rods passed into the nostrils to maintain dorsal elevation and reduction of the nasal bones and septum are recommended by many authors. (Gerrie 1934, Matis 1940, Oldfield and Roberts 1947, Maliniac 1947, Kazanjian and Converse 1959, Sear 1977). Kazanjian (1938) also suggests in appropriate cases, the use of a unilateral splint to prevent re-displacement. This splint is slung from the nose to the cheek contra-lateral to the deviation to maintain over-correction.

The interest shown by the authors quoted previously is not shared by every otolaryngologist. This may be reflected by the all too common sight of the inexperienced junior doctor pushing a few broken noses back into place at the end of a long operating list when the senior surgeons have left the theatre. No thought is put into the manipulation, no splint is put on the nose and even less thought is shown in the after-care.

What chance do patients treated in this manner have of regaining either the shape or function of the nose if the learned experts have difficulty in treating the traumatised nose.

CHAPTER 2.

THE STATEMENT OF THE PROBLEM.

INTRODUCTION.

Of the 1746 cases on the waiting list for surgery in the Department of Otolangology in Edinburgh at the time of writing, 143 cases are listed for septorhinoplasty (8.1%). Ninety percent of these operations are necessitated through trauma. Two hundred and ninety-three patients are listed for a septum operation. The aetiology of these abnormally shaped septums is not so clear cut from the patient's history. A considerable number of these patients do admit to at least one episode of nasal trauma in the past. A clinical impression was formed that the accepted method of treatment of nasal trauma, as practiced in Edinburgh was inadequate.

In November, 1977, a prospective study was set up to determine the aetiology factors involved in nasal bone fracture and to critically assess the different types of treatment. In a 26 month period 1,000 patients with fresh nasal trauma were treated. This represents a referral rate of 38 per month.

PATIENTS AND METHODS.

The patients with nasal trauma in this series were referred from General Practitioners or the Casualty Department of the Royal Infirmary of Edinburgh. More major facial fractures are dealt with in other departments in Edinburgh and are, therefore, excluded from this study. The pro-forma filled in for every patient included:

History:

1. Personal details - age, sex, hospital number.
2. History of previous external deformity - subdivided into bony or cartilaginous.
3. History of nasal obstruction - unilateral or bilateral. Systemic causes of a blocked nose were also noted. e.g. allergy.
4. Cause of the trauma: road traffic accidents, sport, assault or personal. All cases fitted well into one of these four categories.

ASSESSMENT:

1. Soft tissue injury - orbital haematoma, lacerations, soft tissue swelling or epistaxis.
2. Bony deformity - lateral or depressed.
3. Cartilaginous deformity - internal or external.
4. Presence of septal haematoma.
5. X-ray findings.

OPERATIVE DETAILS.

1. Manipulation or no manipulation.

2. Number of days since trauma.

3. Grade of surgeon.

4. Findings with regard to bone and cartilage (fixed, mobile etc).

5. Anaesthetic (full intubation or shore anaesthesia with a bolus of pentothal.

6. Type of fixation (nil, plaster of paris dressing, intranasal packing, tape etc).

7. Immediate assessment of the result.

FOLLOW-UP AT ONE WEEK AND THREE MONTHS.

1. Exclusion of septal haematoma and other urgent complications.

2. Position of the nasal bones.

3. Position of the cartilage.

4. Nasal obstruction.

5. Planning of further nasal surgery to correct any acquired deformity.

There are six consultants, three senior registrars and twelve junior staff in the department. Each individual was encouraged to adopt his "normal" practice of treating nasal fractures. Some individuals chose to attempt an out-patient manipulation soon after the injury if the nose was still numb. This was found to be universally unsatisfactory. Some chose to have the patient anaesthetised for a very limited time by injecting a bolus of pentothal intravenously and then to manipulate the nose quickly back into shape.

Those operators who were particularly interested in nasal surgery tended to have the patient intubated, to allow time for accurate reduction, intranasal packing and a plaster of paris dressing if required. The results of the trial were withheld from the members of the department until it was finished to avoid influencing any particular operator's technique.

RESULTS.

One thousand patients with acute nasal trauma were seen at the Royal Infirmary of Edinburgh in the Ear, Nose and Throat Out-Patient Department in a 26 month period. Three quarters were male 765 (76.5%) and one quarter were female 235 (23.5%). Fig 2.1 shows the age range indicating the high incidence of nasal trauma in the 15-25 years old age group in males. The highest age incidence in females was in the over 60 years old age group. The female preponderance in this age group is more marked if the total numbers of males and females are considered. The male to female ratio is 76.1 to 23.9 that is a multiplication factor of 3.29. It must be taken into account, however, that there are more females than males in this over 60 year old age range in the Lothian area but not to the extent to account for the high female incidence in this group.

Children are in the minority in this series. In Edinburgh, children under the age of 12 years are usually referred to the separate children's hospital for treatment and hence are excluded in the main from this study.

Another factor is that nasal injuries are notoriously difficult to diagnose in children (Moran 1977) and may well not be referred to an otolaryngologist.

FIG 2.1

TOTAL AGE DISTRIBUTION

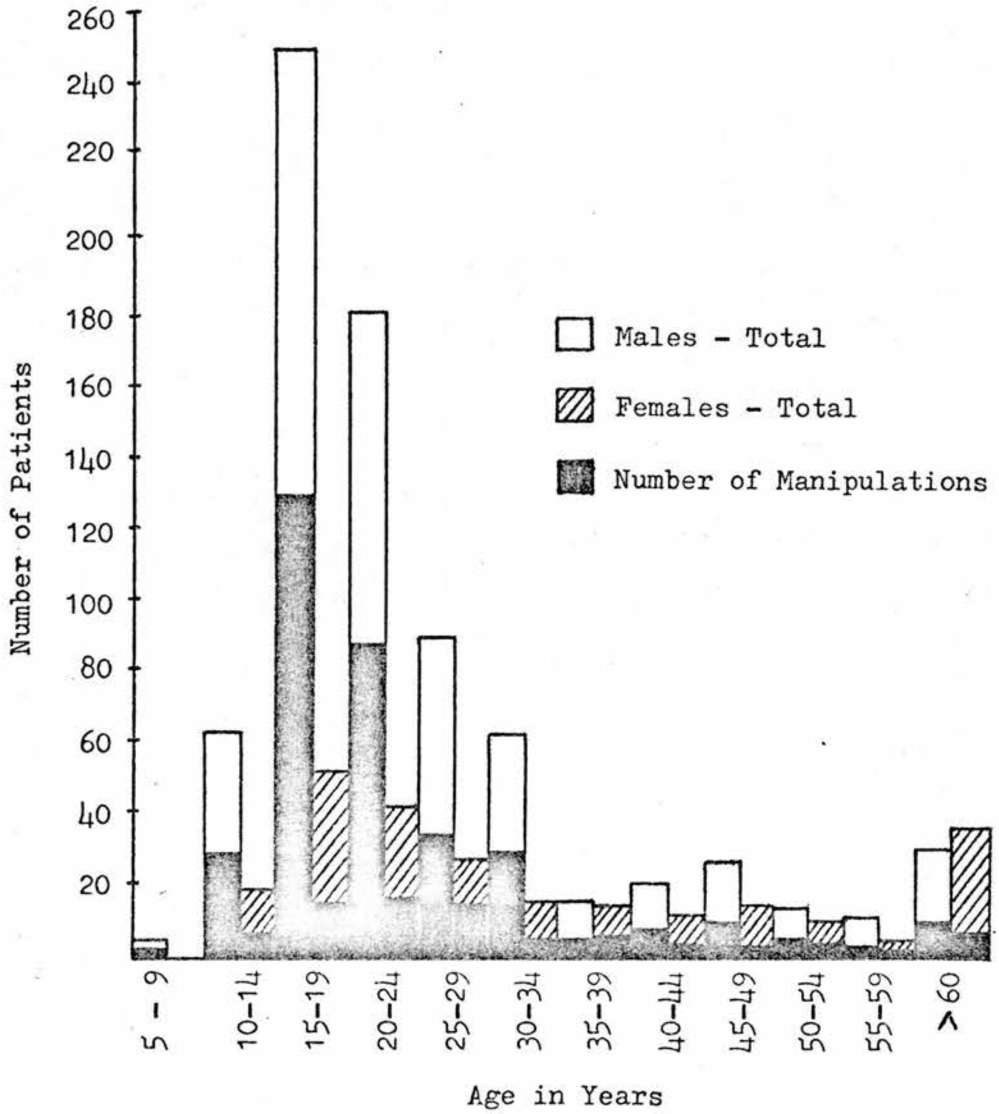
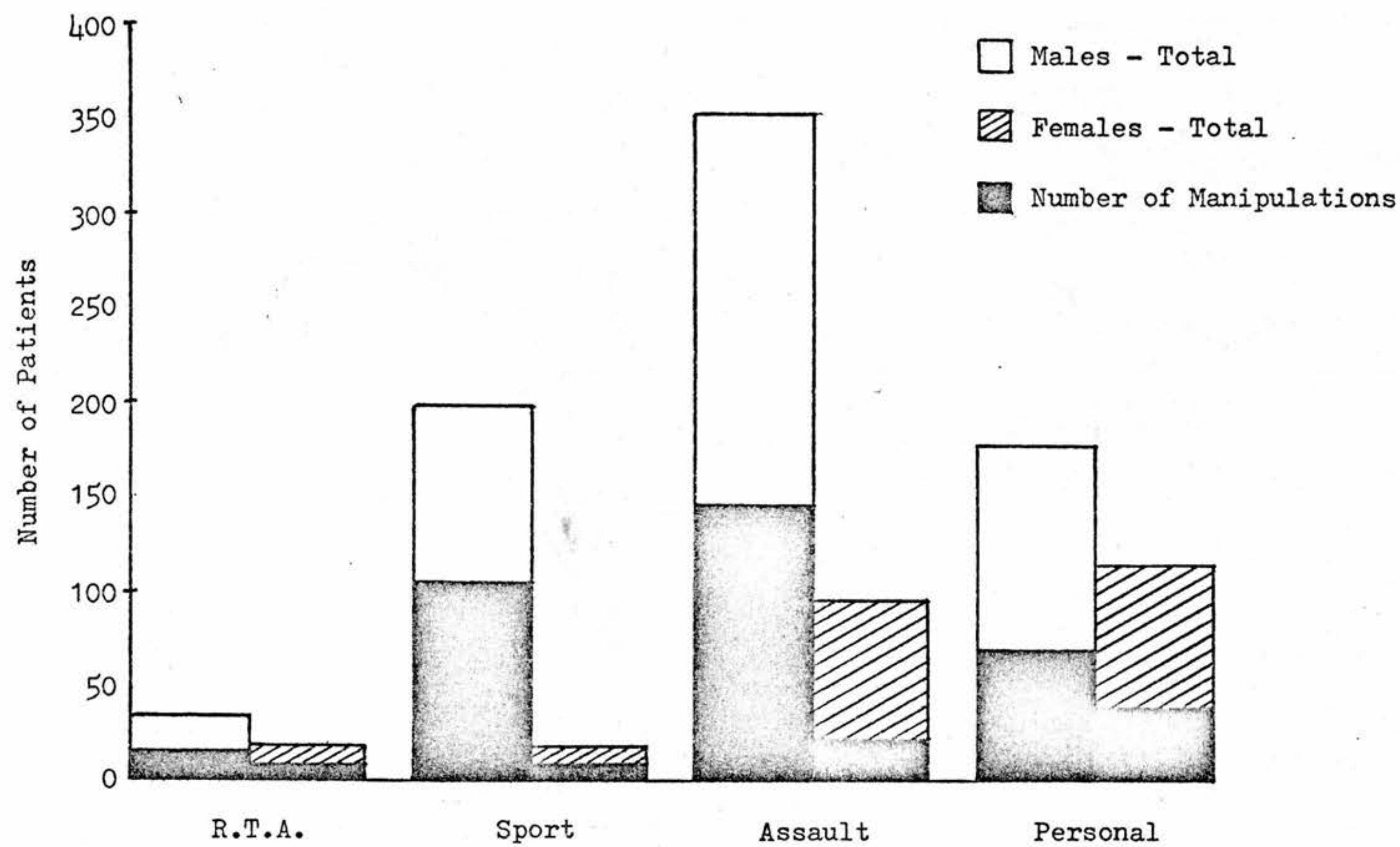


Fig 2.2 demonstrates the aetiological factors involved in our patients to cause nasal trauma. An indication of the male to female ratio is also shown as are the proportion of the patients who required to have an operation. The largest aetiological group is assault and males obviously predominate, but if the correction factor of 3.29 is applied then females almost make up their correct proportion of this group. A large percentage of these patients (70%) admitted to taking alcohol to a greater or lesser degree near the time of the accident. A large discrepancy in the sex ratio occurs in the sport group where there is a proportionately heavy preponderance of males but conversely, in the personal group, although the actual number of males are greater, the proportion of females is higher. This finding is accounted for by the large number of elderly women who fell and damaged their noses.

Over half of the patients did not have any operative treatment 596 (59.6%). The reasons for this were as follows:- 282 had no external deformity and 233 had a symmetrical swelling of the nose and did not have a detectable bony deviation. No fracture was demonstrated radiologically. These latter patients were reviewed after the initial bruising had settled. The clinical impression formed at the time was that the swelling resulted from a subperiostial haematoma. Refusal to have operative treatment accounts for 77 patients in the group and four patients were mentally retarded and epileptic.

These 4 patients constantly traumatised their noses during convulsions. The reasons for the referral on this occasion was merely that this episode was slightly more forceful than usual.

FIG 2.2



TYPE OF TRAUMA

It was not thought to be in the patient's best interest to suggest operative intervention as the fracture was highly likely to be repeated in the very near future. These factors discussed above are summarised in Table 2.1.

Thirty-eight (3.8%) patients stated that they had had nasal deformity prior to trauma. Of those patients who did not need an operation i.e. 515 patients, 63% had a significant epistaxis associated with their nasal trauma.

The standard error of this percentage is 2.13%. Thus the 95% confidence limits are 58.8% to 67.2%. Of those patients who did have a nasal fracture with deviation from the previous shape i.e. 485 patients, 71% had a significant epistaxis at the time of trauma. The standard error of this latter figure is 2.06 and the 95% confidence limits are 67.00% to 75.00%. There is, therefore, no significant difference between these figures. No diagnostic value can, therefore, be attached to the presence of epistaxis in nasal trauma from this series.

Radiographs of the nasal bones were routinely made. Two standard views were used - anteroposterior and lateral. Of the 404 patients who were subsequently manipulated, 351 (87%) had a fracture on X-ray. This fracture was determined either by a radiologist or an otolaryngologist. The opinion of a casualty officer in these circumstances was not necessarily accepted. There was, however, a fracture present on the radiographs of 43 (15.2%) of the 282 patients with no external deformity.

Eight (0.8%) patients had a septal haematoma on initial presentation. All of these patients had the haematoma formally incised and drained with no further complications under general anaesthetic. Eighteen (1.8%) of the injuries were compound.

Forty patients (4%) had a unilateral depression of the nasal bone with no other involvement. The commonest bony deformity was lateral displacement which was present in 340 (34%) patients. Twenty-Four patients (2.4%) were diagnosed as having a depressed nasal pyramid, the nasal bones being displaced backwards comminuting the ethmoids. Only those patients who had operative treatment were accurately diagnosed.

Thirty-Two patients admitted to having an old external cartilaginous deformity while 125 patients complained of a newly acquired cartilaginous deformity from the nasal trauma.

Of the 404 (40.4%) patients who had operative treatment, 329 (81%) were male and 75 (19%) were female. To express this in another way, 43.0% of all males and 31.9% of all the females required to have a nasal manipulation.

The standard error of the males (43.0%) is 1.79% which gives a 95% confidence limit from 38.5% to 46.5%. The standard error of the females (31.9%) is 3.04% which gives the 95% confidence limits from 25.9% to 37.9%. The percentage of males who required manipulation is, therefore, significantly greater than the percentage of females.

The variables involved were:

1. surgical grade of operator.
2. time since trauma
3. type of anaesthetic.
4. the use of a plaster of paris splint.

The results were assessed initially at one week to exclude any urgent complications of the operation and to remove the plaster of paris splint. The definitive assessment, however, was performed at three months. The results are tabulated in Tables 2.2, 2.3, 2.4, 2.5.

The time elapsed between the trauma and reduction was divided into three groups:-

1. within 7 days.
2. 8-14 days.
3. Longer than 14 days.

The results are shown in Table 2.5.

The operation was deemed unsuccessful if, in the opinion of both patient and examiner, the nose had deviated from the midline with the end result worse than prior to trauma. The results from the operation were, therefore, classified as either good or bad. The influence of the various factors from the results of the operation are summarised thus:-

The grade of operator gave a χ^2 value of 0.04060 3 D.F. $P > 0.5$

The type of anaesthetic gave a χ^2 value of 0.08446 1 D.F. $0.5 > P > 0.1$

The use of plaster of paris splint or not gave a value for χ^2 0.4214 1 D.F.. $P > 0.5$.

The effect of delay of manipulation following trauma likewise was not shown to be significant. $\chi^2 = 4.46$. 2 D.F. $0.5 > P > 0.1$.

It would appear from these results that there was no influence from any of the previously mentioned variables on the long term end results of manipulation of the nasal bones.

125 patients had a newly acquired external deformity of the cartilaginous septum. Following manipulation, 45 still had the deformity three months after operations. This means that 80 patients were improved back to normal. However, it was estimated that 67 patients septums were improved merely by manipulation of their bones whereas thirteen were improved by manipulation of the septum by forceps. This represents a "success" rate of septal manipulation of 10%.

One male patient developed the only post operative septal haematoma in this series following manipulation. This unfortunately became infected and formed an abscess. The abscess was drained and an indwelling rubber Dam drain was used for some days but absorption of the septal cartilage led to subsequent cartilaginous dorsum collapse obvious at the three month follow-up.

The initial default rate of out-patient attendance at three months was 30%. Efforts were made, however, to persuade patient re-attendance at the out-patient clinic. This eventually meant a true default rate or no adequate assessment at three months of 18%. The assessment of these latter group of patients was, therefore, taken at the weekly follow-up at which the default rate was less than 1%. The overall failure rate was 40.6%. This assumes those patients with a previous deformity are excluded. If they are included in the failure rate then the failure percentage rises to 47%. One Hundred and Thirteen (28%) patients who had a manipulation and who had a poor result from the manipulation declined further surgical interference. Sixty percent of the failures did not want further surgery. Of these patients, 81 (72%) were male and 32 (28%) were female. The correction factor of 3.29 as previously quoted brings the female percentage to above the male percentage. This means although females intended to be dis-satisfied with the results slightly more than males, they were not prepared to undergo a further operation.

Forty-One (10%) of post manipulation patients required surgery for functional difficulties i.e. newly acquired septal deformities interfering with nasal respiration. Thirty-Six patients (9%) required cosmetic and functional surgical correction of the newly acquired deformity.

Twelve of these 36 patients (3 females) were operated on purely for cosmetic reasons i.e. 65 (16.1%) patients had inadequate airways following their manipulation. Therefore, 77 patients were added to the waiting list for surgery in this 26 month period purely as a result of nasal trauma.

It was the author's clinical impression, although unfortunately no figures are available in this series, that a significant number of patients with nasal trauma whether or not they have a nasal manipulation, subsequently presented with some degree of rhinitis. In these patients, the inferior turbinates were markedly enlarged. The underlying cause for this phenomenon is at present unknown.

All nasal manipulations were performed at The City Hospital which is the in-patient centre for E.N.T. patients in Edinburgh. The number of nasal manipulations performed annually at this hospital over a 10 year period 1969-1978 seems remarkably constant. Table 2.6.

The average number of cases per year is 287.7 patients. In the years 1975 and 1976, there is an unexplained dip in the numbers. This is presumably a result of lack of interest in the operation by junior medical staff over those years. Other out-patient departments in Edinburgh also send patients to have a nasal manipulation in the same hospital which explains why only 404 patients are included in this series over a 26 month period whereas the average number of patients who have a nasal manipulation in 12 months is 287.7.

INACCURACIES OF METHOD.

1. This study was initiated because of the author's impression of the inadequacy of accepted treatment of nasal fractures. At that time, as little upset to the routine was planned in keeping with the needs of the study. Accordingly, a number of doctors were involved in the assessment treatment and follow-up of these patients. This led to unevenness in the differing interests and attitudes shown in this study. The author, however, assessed and treated 30% of cases himself. When the study was terminated, at the convenient figure of 1,000 patients, a special clinic was begun to cater solely for fractured noses. All referrals were seen by the author exclusively. The results from this clinic are reported in Chapter 6.

2. The number of consultant manipulations were, compared to junior staff, very low. This, however, is the practice in the Department and the United Kingdom hence the all-round treatment plan is assessed rather than attempting to skew the results by encouraging more consultant manipulations.

3. The timing of follow-up was agreed as a balance between accurate assessment of shape and function of the nose after operation which would ideally be a longer time and the default rate which was high at three months but would be considerably more at six months.

4. The patient's idea of the shape of the nose is naturally inaccurate in many cases. The accuracy of comparison of the pre-traumatic and post-operative shape of the nose was high, particularly when advice was sought by the patient from his peers and parents.

4. Pre-traumatic social photography was excluded as a means of identifying the shape of the nose owing to the lack of standardisation of views. Those patients who were not manipulated at time of presentation were not re-assessed routinely but of all these 596 patients, none have returned to date (October, 1981) wishing further funcational or cosmetic surgery as a result of the incident of nasal trauma.

The degree of "failure" of the operation naturally is dependent on the opinion of the patient. A slight inaccuracy in alignment of the bones may be unacceptable in a pretty young model but quite acceptable in a 50 year old alcoholic labourer.

DISCUSSION.

Nasal trauma is common. Fry (1976) believes that nasal fractures are the most common fractures. Dingman and Natvig (1964) agree there is a high incidence of nasal fractures but second to fractures of the clavicle and wrist.

The hospital out-patient department involved in this study serves about 0.5 million people.

The referral rate quoted tallies closely with that found in the similarly sized city of Gothenberg, Sweden in a series of nasal fractures by Lundin et al (1973). These authors also identify various aetiological agents. One of the most common is road traffic accidents. The apparent rise in cases of nasal trauma has been thought by some to be directly related to the increase in use and the higher speeds of cars. (Straith 1937a, b, Woodward, 1935).

The various aetiological factors may be compared in incidence with other series.

Author	Percentage			
	R.T.A.	SPORT	ASSAULT	OTHER
MURRAY (this thesis)	4.8	21.5	44.8	28.9
SCHULTZ & DEVILLIERS 1975	40	25	15	20
MAYELL 1973	37	15(falls included)	26	22
LUNDIN et al 1973	10.5	17.1	45.7	26.6
GERRIE 1938	15	23	20	42
SCHULTZ 1970	54	17.3	6.5	22.2

Lorre and Ampe (1964) found in their series motor cycle accidents provided 19% of their patients. The explanation of the very low incidence of road traffic accidents in our aetiological group may be that the more major facial fractures which are commoner in high velocity traumas such as car accidents (Hoffman 1980) are treated in other departments.

This department deals with isolated nasal fractures. The most common mode of injury is a passenger or driver hitting the dashboard or the steering wheel when the vehicle comes to a sudden stop. The incidence of alcohol consumption near the time of the accident was difficult to estimate accurately as most patients were rather reticent about this.

The commonest injury sustained in sport occurred in soccer when two people went to head the ball at the same time. The player in front moves his head backwards to head the ball and fractures his opponents nose. Rugby was a less common game to produce nasal injuries but the predominent sport in the female category was hockey; the damge caused by over active use of the hockey stick. The almost overwhelming preponderence of young males in the large assault group presumably reflects these people attempting to demonstrate their virility by fighting. A large majority of these patients had taken alcohol to excess prior to the assault.

The damage done to the modern day pugilist's nose is interesting. The incidence of a fractured nose sustained in a boxing match is extremely low. Tucker et al (1964) report two fractures in 4,350 bouts. The septum appears to chronically hypertrophy with subsequent loss of the cartilaginous dorsum. The perpendicular plate of the ethmoid hypertrophie and the bony septum is often displaced. (Pakowski 1964, Cohen 1949, Seltzer 1950, Zorzoli 1950b, 1951).

The incidence of isolated nasal trauma compared with more major facial fractures is difficult to estimate because of the variety of specialists who may deal with this problem. Georgiev (1970) reports 22% of his facial trauma cases were purely nasal trauma compared with Schultz (1970) whose study of 400 consecutive cases of major facial trauma showed a 32% incidence of purely nasal fractures. Thirty-nine percent of the patients of Lundin et al (1973) compares with a 53% incidence of Kaban et al (1977) of isolated nasal fractures.

The association of signs and symptoms with a nasal fracture have been fully documented but in keeping with the author's series, no relevance has been attached to them. (Becker 1948, Drumheller 1970b). These include epistaxis, crepitation, septal displacement, lacerations, haematoma, twisting, perforation or loss of septal height.

Nasal radiographs were not found to be of great benefit in this series. There would appear to be a concensus of opinion on this point. (Cohen 1923, Cox 1935, Becker 1948, McLemore 1952, Gosserez 1956, Caparosa and Zavatsky 1957, Joseph, 1975). Even if the radiographs were positive, the author felt there is no reason for manipulation unless there is an associated deformity (Lowenthal 1953). Conversely, Schultz (1970) believes that if the X-ray shows displacement while the nose looks straight, the nose should be manipulated because otherwise the result is poor. The most helpful view to diagnose a fracture of the nasal bone appears to be the occlusal film which was not performed routinely in this study (Hurst 1960, Lowenthal 1953) but may well be of greater relevance than the other standard views although displacement may be difficult to judge accurately.

If there was dubiety in our patients whether or not the bones had been displaced owing to gross swelling, the nose was re-assessed when the oedema had disappeared. The pre traumatic shape of the nose is difficult to define accurately. This has an obvious bearing on the post manipulation shape of the nose. In contrast to Mayell's series (1973) which contained 30% of previously mishapen noses, our series has only a 3.8% incidence of a pre-traumatic deformity.

The results of the operation of nasal manipulation have been called into question by a number of authors. Many equally eminent surgeons feel that it is a good worthwhile operation. (Schultz 1970, Schultz and Devilliers 1974).

The "failure" rate in this series of between 31% and 46% depending on the perameters measured is in accordance with other series. (Woodward 1935, Mayell 1973, Harrison 1979 Pirsig 1981). These authors have analysed their results in contrast to the proponents of the operation who depend on clinical impression to support their dogma.

Hurst (1960) divides the results of nasal fractures depending on the type of fracture. He believes the manipulation of greenstick fractures gives 100% good results. If the fracture is linear with no displacement, again a perfect result is achieved. A displaced linear fracture, a depressed linear fracture and a comminuted fracture give poor results in 25%, 45% and 70% of cases respectively. Overall, 50% of Mayell's series (1973) developed airway problems subsequent to nasal manipulation.

This series was conducted from a plastic surgical unit. These surgeons are not specifically trained to examine the septum. This may mean that this is not a true reflection of septal deformity, but may be associated with a degree of post-traumatic rhinitis. In the author's series, 16.1% (65) of the patients required septal surgery to improve their breathing.

The possible causes for such a high failure rating include the requirement for the reduction to be millimetre perfect, the lack of strong muscles to remodel the bones if they are slightly out of alignment and the contraction of the fibrous healing of membranous bones.

Janeke and Wright (1973) screened 70 cadavers and found 7 with obviously deviated noses. They used 4 cadavers as a control. Of the 7, five noses were removed in total and studied histologically.

There was microscopical evidence of osseous healing but fibrous healing was present around the fracture site. The frontal process of the maxilla was the most common site for fibrous healing. Two deviated noses were examined under magnification, there was no obvious fibrous tissue at the areas of thickened bone which were presumably old fracture sites.

Crawford (1963) believes that fibrous healing is more common in lateral deviations of the nose. It would appear obvious that if fibrous healing does occur at a nasal fracture site, it would occur at all the fractures on both sides of the nose which, in turn, would produce an equal pull on the nasal bones with no subsequent displacement.

From the literature, it would appear the most important factor is probably the alignment of the nasal septum. If an operation boasts a 47% "failure" rate then clearly steps must be taken to identify the causative factor and eradicate it.

The remainder of this thesis is devoted to identifying and eradicating this factor.

CONCLUSIONS.

1. Nasal trauma is common.

2. The commonest age and aetiological factors are young males involved in assault.

3. Radiographs are of little help.

4. The results of nasal manipulation are poor. Failure rate of 40.6%

5. The grading of the operator, the type of anaesthetic used, the use of a splint and the time elapsed until treatment have influence on the final outcome.

TABLE 2.1.

TYPE OF TRAUMA.

Cause	R.T.A.	Sport	Assault	Personal
Percentage of total:	4.8	21.5	44.8	28.9
Total number:	48	215	448	289
Total manipulated:	20	113	164	107
Total Males:	32	199	353	177
Number Manipulated:	13	105	143	68
Total Females:	16	16	95	112
Number Manipulated:	7	8	21	39

TABLE 2.2.

EFFECT OF GRADE OF OPERATOR.

	NORMAL	WORSE	TOTAL
SHO	41	40	83
REG	117	112	229
SR	32	22	54
CONS	22	16	38
	214	190	404

$\chi^2 = 0.4060$ 3 D.F. $P > 0.50$

TABLE 2.3.

EFFECT OF ANAESTHETIC.

	NORMAL	WORSE	TOTAL
ETT	104	102	206
NO ETT	109	89	198
	213	191	404

$\chi^2 = 0.8446$ 1 D.F. $0.50 > P > 0.10$

TABLE 2.4.

EFFECT OF PLASTER SPLINT.

	NORMAL	WORSE	TOTAL
POP	39	30	69
NO POP	175	160	335
	214	190	404

$\chi^2 = 0.4214$ 1 D.F. $P > 0.5$

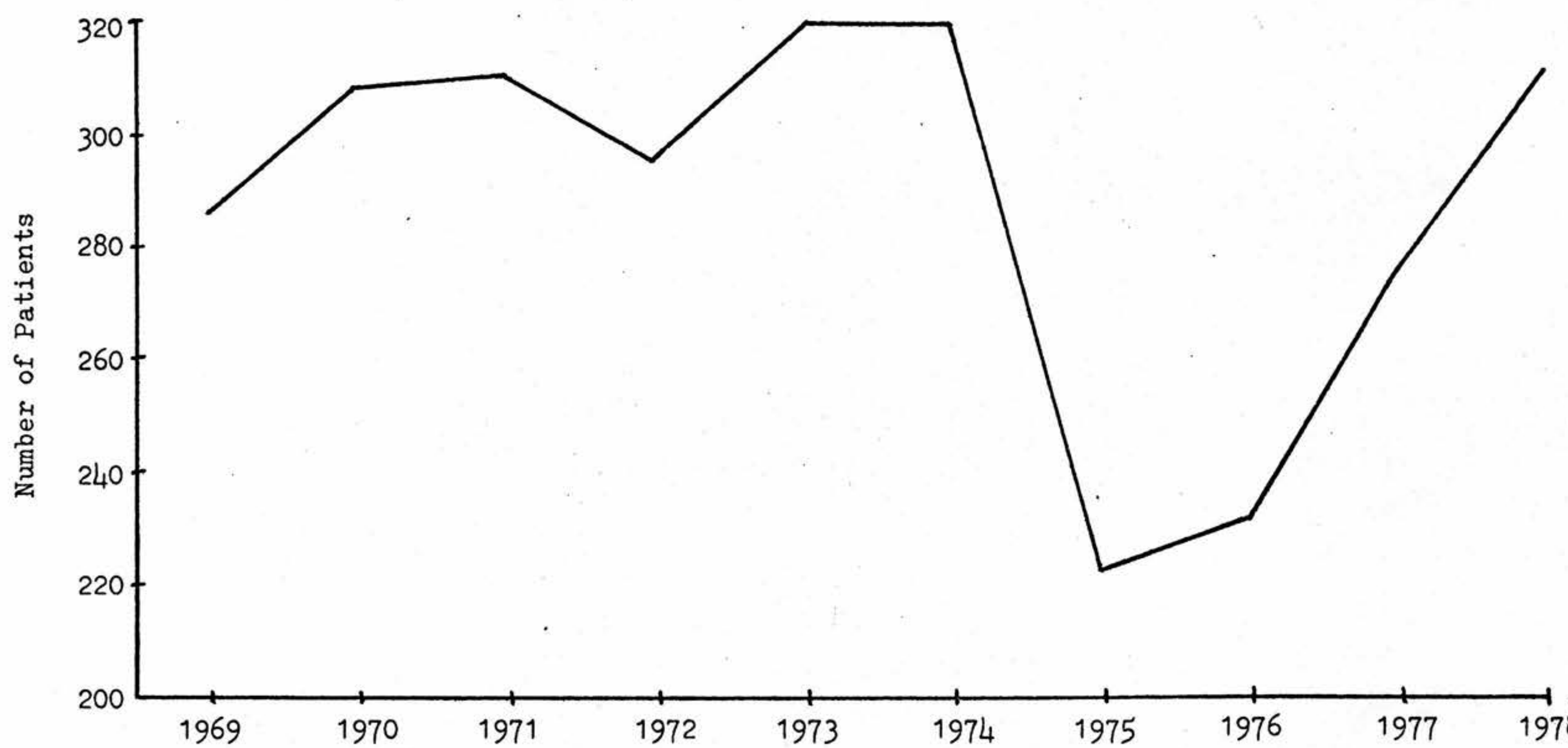
TABLE 2.5.

Effect of days since trauma on results of manipulation.

Days	Total	Post Operative Bony Deformity	Preoperative Bony Deformity	Ratio of Failure	Age Failure
0-7	174	74	16	58 of 158	37
8-14	194	102	24	78 of 170	46
>14	36	14	4	10 of 32	31

$\chi^2 = 4.46$ 2 D.F. $0.5 > P > 0.1$

TABLE 6



NASAL MANIPULATIONS PERFORMED AT THE CITY HOSPITAL, EDINBURGH

CHAPTER 3.

PATHOLOGICAL DESCRIPTION OF NASAL FRACTURES.

INTRODUCTION.

The nasal pyramid is a complex structure. It is made of different materials to form a characteristic shape. Many descriptions of the lines of nasal fractures have been written but no one author has summarised the fracture in the way Le Fort described facial fractures. Each author describes what he feels are the salient features but in only a few are these diagnostically or therapeutically helpful classifications. The following is, therefore, a distillation and clarification of multiple, often conflicting views.

Kazanjian (1933) describes three types of nasal deformity:

1. Loss of skin only.
2. Loss of part of the framework skin and mucous membrane.
3. Loss of framework only.

In particular, he divides nasal fractures into one simple nasal bone fracture, nasal bones and septal fractures and severe comminution of the nasal bones with severe septal deformities.

This rathercrude classification has been subsequently refined. Nasal bone fractures may be greenstick (Kelly 1937, Lowenthal 1953) which are more common in children than in adults or a true fracture. True fractures may, in turn, be complete or incomplete. A single nasal bone fracture is usually linear and may be displaced or undisplaced. Usually, the latter is a depressed fracture of the nasal bones. These latter fractures require to be elevated to restore normal continuity of the nasal pyramid.

The results of treatment of this type of fracture are said to be good (Harrison 1979). The force normally comes from the lateral direction to create this fracture and the nasal bone is fractured along the line where the bone changes from thick to thin. (Miller 1951, Aubry et al 1966). A moderate force aimed a little lower on the nasal bone may fracture the fragile inferior edge. This is an important fracture which does not require active surgical treatment.

In the adult, the internasal suture is firm and therefore when the nasal pyramid is fractured, the bony dorsum is intact but the whole unit shifts over. The septum is said to be involved in this fracture (Gollom 1963, Harrison 1979).

This fracture comes from lateral trauma (Aubry et al 1966). More force in a lateral direction comminutes the nasal bones. The septum is involved with this fracture also. The whole arch may be flattened (Moore and Harris 1940).

A fracture of the nasal cap has, in the past, been atributable to a sideways glancing blow (Battle 1964) but it has been shown in cadavers (Harrison 1979) that it is only possible to reproduce this fracture by direct frontal violence of moderate severity directed against the upper part of the nose. Both nasal bones were fractured in their lower one centimetre and the "cap" of the pyramid was pushed back and splayed the nasal bones. An associated septal fracture was common.

Frontal trauma in children may push the nasal bones backwards and disrupt the internasal suture. This, according to Aubry et al (1966) is a fracture peculiar to children.

Becker's (1948) classification of nasal fractures which is the most widely quoted of greenstick,linear,frontal, lateral frontal or fracture from below is not of relevance. It appears to be a mixture of the direction of the trauma and a pathalogical description of the lines of fracture.

Septal involvement in nasal bone fractures is prominent in a severely traumatised nose. This involvement may take the form of the fracture of Jarjavay. This fracture line runs parallel with the maxillary crest from the anterior maxillary spine to the vomerine angle. This is a common fracture (Aubry et al 1966, Moore and Harris 1940).

Inferosuperior trauma to the tip of the nose can cause the fracture of Chevallet (Aubry 1966). This runs from the anterior nasal spine to immediately under the nasal bones.

This latter fracture may be solely cartilaginous but obviously may occur along with nasal bone fractures. The third cartilaginous septal fracture recognised by Aubry et al (1966) runs parallel with the caudal end of the septum. This fracture is very rare.

According to Masing (1965) and Kazanjian and Converse (1959), a blow from the front on to the cartilaginous septum may cause the septum to slip out of the sulcus on the floor of the nasal cavity. Such a dislocation is more likely in the vomerine area than anteriorly. External nasal deformity may be caused by dislocation of the upper lateral cartilage. Normally, there is apposition of the upper lateral cartilage under the free edge of the nasal bone by a single connective tissue membrane. This very thin structure is made up of fused periosteum and perichondrium.

Tipton (1971) feels that separation of the cartilage may mimic a depressed fractured nasal bone. This dislocation requires to be sutured in place over a piece of rubber tubing otherise the nose will still be deformed after reduction. Tipton (1971) found that this deformity occurred in about 5% of his patients with nasal trauma but this clinical impression has not been substantiated by other authors.

Gollom (1963) suggests an open reduction operation for the treatment of a dislocation of the alar cartilages from the nasal bone but does not quote any figures regarding the incidence of this deformity.

Other fractures have been mentioned by authors but less agreement on these is apparent by the number of papers which quote them.

Cox (1935) describes a fracture of the nasal process of the superior maxilla, a fracture of the nasal spine and a fracture at the nasal frontal suture.

The nasal spine fracture is also mentioned by Cohen (1949), Whitham (1949) and Gosserez (1956). Goldman (1964) places emphasis on the behaviour and mechanics of the sutures between the nasal bones and the nasal processes of the maxilla. These sutures may dislocate with injury but rarely fracture. The elasticity of these sutures requires the dislocation to be replaced usually with Walsham's forceps. Impaction of the nasal bones beneath the frontal process of the maxilla is also noted by Thompson (1966).

The involvement of the septum with nasal bone fractures is fully documented. Although Williams in 1910, stated that most septal problems lay in the cartilaginous part and only rarely was the bony septum involved in nasal trauma, subsequently, many authors have refuted this.

The septum is, undoubtedly, the keystone or buttress of the nose (Miller 1951). Metzenbaum (1941) felt that if the nasal bones were depressed, the bony septum is also fractured. Gillies & Kilner (1929) suggest the septum is fractured in the upper part and moves with the fractured nasal bones. The area most commonly involved would appear to be the posterior two-thirds of the cartilaginous septum and the anterior one third of the bony septum (White 1931, Woodward 1935, Whitham 1939, Moore & Harris 1940).

The nose of the pugilist reflects a chronic form of low grade trauma to the nose. The authors who describe their findings agree that the bony septum becomes quite damaged. In particular, the perpendicular plate of the ethmoid hypertrophies and the vomer may become displaced (Cohen 1949, Zorzoli 1950). The cartilaginous septum is also damaged however, to the stage that eventually almost complete destruction results and no further bleeding occurs (Seltzer 1950). Masing (1965) describes two weak points on the cartilaginous dorsum from this study on cadavers. The weakest area is the connection between the cartilaginous septum and the upper lateral cartilages.

The second weakest point was located just below the "Y shaped" junction of the upper lateral cartilage. Injury of this area is difficult to detect in an acute nasal trauma.

Many other classifications e.g. Safian and Tamerin (1936) and McKenzie (1950) were merely descriptions of the appearance of the traumatised nose and are of little value either diagnostically or therapeutically. The importance of the presence of even minor septal fractures is emphasised by Cottle (1950). Inadequate treatment at an early stage may lead to problems in later years.

Although some agreement is reached by authors quoted above, good evidence of the pattern of septal fracture and involvement in nasal trauma is lacking. The evidence presented so far has been mainly of clinical origin. Harrison (1979) struck a number of cadavers on the nose and described the fractures created. There were several inadequacies in his experiment and this chapter describes a more scientific approach whereby considerably more information is gleaned from cadaver work.

METHODS AND MATERIALS.

Fifty unembalmed post mortem cadavers kept refrigerated within twenty-four hours of death were used for the experiment. The cause of death in each was unrelated to any metabolic or wasting disease. The majority had died from either myocardial infarction or a cerebrovascular accident. Because of the nature of the experiment, all the bodies were in the older age groups. Any body with a markedly deviated external nose was excluded from this experiment. The assessment was performed in the following manner: The nasal bones were graded in the following manner:

Grade 0 — The bones were perfectly straight.

Grade 1 — The bones were straight or only deviated from the midline up to one half a nose bridge width.

Grade 2. — The bones were deviated from the midline between one half and a full bridge width.

Grade 3. — The bones were deviated from the midline greater than one full bridge width.

Grade 4. — The bones were deviated so much that they were almost touching the cheek.

In fact, all the bodies used fitted into Grade 1.

This grading system which is used in subsequent chapters was devised to give some idea of external nasal deviation. The use of the term straight or deviated is a very subjective comment on the part of the examiner. A physical measurement was not performed as the actual distance is not of relevance, more important is the relative size and measurement compared with the size of the face. A small petite face will be disfigured with a nose deviation of a small number of millimetres whereas in a large, fat face, this may not be noticed.

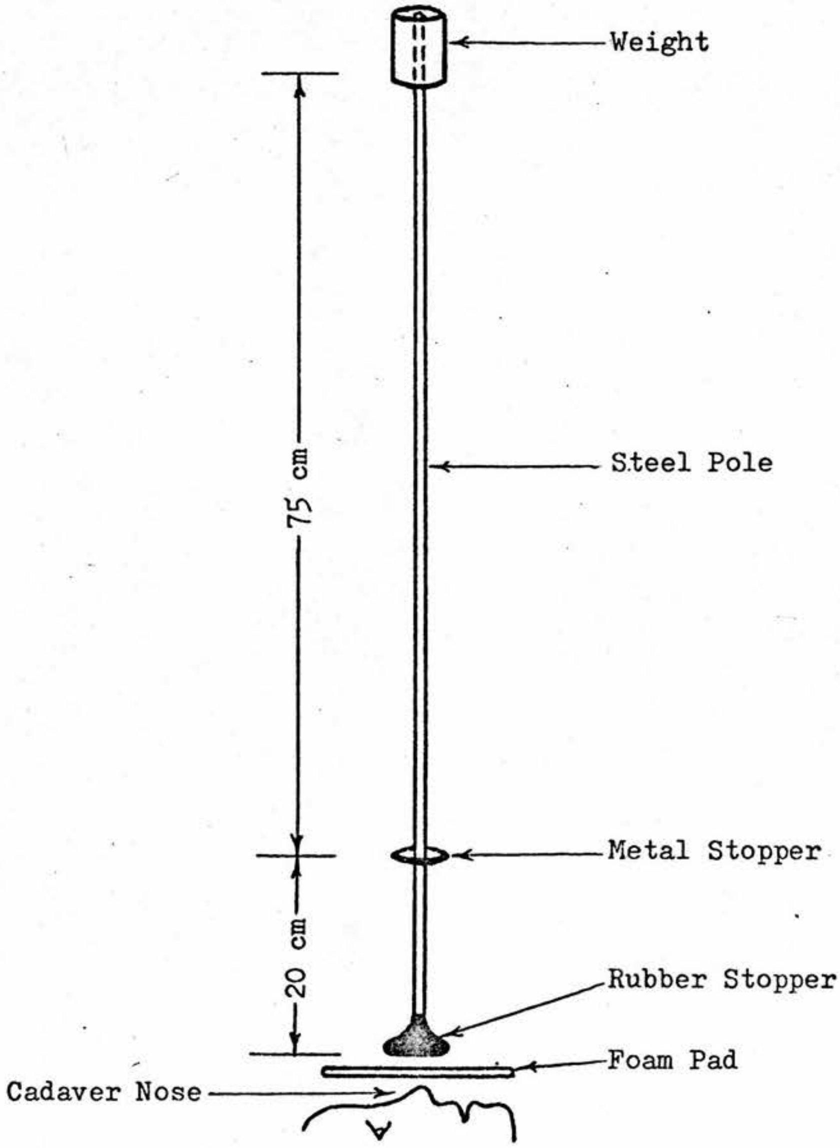
No cadaver had a perfectly symmetrical internal septum. Clinical judgment was used to exclude any cadaver with a major septal deviation from the trial.

A long, straight, steel pole of one metre was constructed with a metal stopper soldered on 20cm from the bottom. A rubber stopper was placed on the end which in turn was placed on the cadaver's nose. (Fig 3.1).

A foam pad was interposed on the nose to avoid undue skin damage. This latter was pre-requisite for the experiment to avoid undue distress to the relatives at an already harrowing time.

Varying weights were dropped over a distance of 75cm through the influence of gravity and the force passed on to the nose. The rubber stopper was applied to the nose in various positions to simulate the clinical situation. A variety of objects are used in vivo to fracture a nose i.e. forehead, occiput, fist, boot, weapon etc. All these may hit the nose in a characteristic fashion with varying degrees of force, velocity and angle.

Fig 3.1



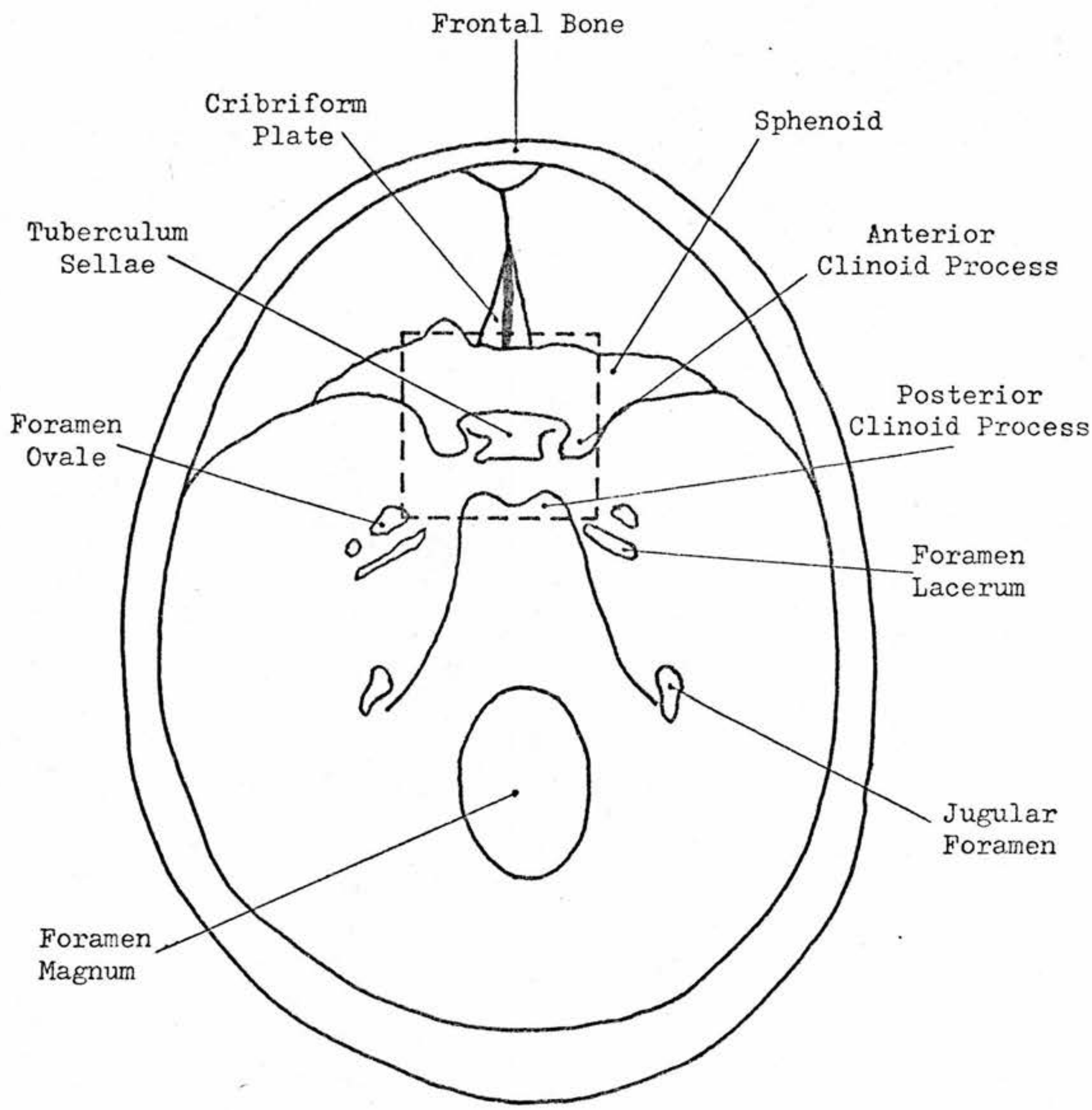
INSTRUMENT USED TO CREATE THE NASAL FRACTURE

The mechanism constructed attempts to average these infinite variables and to allow the force to meet the nose over a maximum area rather than a pin-point. When there was an obvious palpable fracture, the skin from the forehead was reflected down forwards over the nose. The fracture lines of the nasal bones were then confirmed. Anterior rhinoscopy was used to identify any gross septal damage.

Part of the sphenoid was removed from the skull base following removal of the brain to allow adequate vision of the posterior end of the septum (Fig 3.2). As far as possible, acquired septal deflections were noted leaving the mucoperichondrium intact, but in some bodies, a submucous resection of the cartilaginous septum afforded a clearer picture of the state of the septum. The septum was then removed under direct vision to determine any fracture lines. Diluted india ink was run over the septum and viewed microscopically (x 10 magnification) to show incomplete fractures. The one area which it became apparent was vitally important to see was the perpendicular plate of the ethmoid immediately underneath the nasal bones. The best method to see this was to remove, temporarily, the mobile fractured nasal bone at the time of confirmation of the fracture lines. A routinely performed submucous resection of the nasal septum was found not to include this area in the removed septum and attempts at removal of the perpendicular plate of the ethmoid merely caused fresh fractures.

The most important clinical fracture from the introductory study is the pyramidal fracture.

Fig 3.2



---Lines of Resection Removed at Level of Hard Palate

INTERIOR OF SKULL TO SHOW LINES OF RESECTION OF SPHENOID

This fracture was produced experimentally considerably more often than the other fractures to allow more detailed assessment of the fracture lines. In these cases, the force was always directed in an antero-lateral direction to the nose and a typical fracture of the nasal bones was created. The force required to create this fracture was noted as was the degree of acquired deviation of the nasal bones from the midline i.e. the original position. A similar method as before was used to demonstrate any extension of the fracture into the septum.

A correlation between the degree of deviation of the nasal bones from the midline and the involvement of the bony septum in the fracture was made. The external shape of the nose was assessed in a manner similar to that used before the nose was hit. The last 10 cadavers were subjected to the force falling only on the cartilaginous septum.

In five, the force came from directly above and onto the dorsum and in five, the force came from an inferoantero-lateral direction onto the lower lateral alar cartilage. The cartilaginous septum was examined as previously described. Seven cadavers were used as controls. No force was used to damage the nose but otherwise the procedure was identical to that used for the experimental bodies.

The force required to create the fractures were calculated using the following equation:-

$$\text{Force} = \frac{\text{mass x acceleration of gravity x height.}}{\text{Area}}$$

Three weights were used, namely 790gms, 1540gms and 4830gms. A combination of these were used throughout the experiment giving the following weights - 6,370gms, 2,330gms and 7,160 gms. The height used through which the weights fell was 0.75m. The area of thrust on the nose was calculated as follows: the area used in the lateral experiments was a circle - the size of the stopper. The radius was 1.5cms and therefore, using the formula πr^2 the area is $0.000707m^2$. The possible forces used on this are:

1. 8,221.22 Pascals.
2. 16,026.311 Pascals.
3. 50,264.07 Pascals.
4. 66,290.38 Pascals.
5. 24,247.52 Pascals.
6. 74,511.60 Pascals.

The area for the frontal assault was measured as 1.5cm long and 1cm wide. This area is $0.00015m^2$. The possible forces for this area are:-

1. 38,749.33 Pascals.
2. 75, 537.33 Pascals.
3. 236,911.33 Pascals.
4. 312,448.66 Pascals.
5. 114,286.66 Pascals.
6. 351,198.00 Pascals.

The results are tabulated - Tables: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8.

RESULTS.

Fifty cadavers were used in the experiment, 23 males and 27 females. Seven bodies were used as controls. The average age of the bodies was 71.6 years. The various types of fracture are described below. Seven broad classifications were seen with a few minor variations.

1. The simple nasal bone depression: The fracture lines run parallel with the dorsum and nasomaxillary suture. They turn to join each other two-thirds of the way up the nasal bone where the bone changes from thin to thick. The septum was left entirely free from this fracture. Eight bodies sustained this type of fracture. In all, the direction of force was lateral. Five bodies required a force of 50,264,07 Pascals to create this fracture but two bodies only required 16,026.31 Pascals and in one body, the nasal bone fractured with a force of 24,247.52 Pascals. Three of the bodies which required the greatest force to break the nose were female and one female only needed the smallest force. The middle force was used in a female body. The direction of the force was lateral.

In all the bodies, it was found that there was an apparent deviation of the nose from the midline of a Grade 1 type but in fact, when the distance from the inner canthi was measured to the dorsum, the nasal bones were found to be midline or within a deviation of half a nose breadth.

2. The bony dorsum is intact but the fracture lines run parallel to the dorsum. The ipsilateral nasal bone is fractured parallel to and immediately above the nasomaxillary suture running up to the thick part of the nasal bone. The contralateral nasal bone was fractured parallel with the dorsum but immediately below it. The fracture line connects the two described fractures across the midline where the bone changes from thin to thick. The cartilaginous septum is fractured about 0.5cm below the dorsum in the bony septum. This area is difficult to assess in the normal clinical situation. The fracture line runs backwards into the perpendicular plate of the ethmoid for about 3cm where it extends under the root of the nose to the skull base. The external shape of the nose is noted to be deviated to a Grade 2 deviation.

Fifteen bodies sustained the fracture of which 9 were female. Eleven of these bodies had lateral violence, two required a force of 16,026.31 Pascals to create the fracture. Seven needed 50,264.07 Pascals and two were hit with 66,290.38 Pascals. Six of the eleven bodies were male, one only needed the least force, one needed the largest force and four required the middle force to create the fracture.

All the four bodies subjected to frontal trauma were female. Two cadavers required a force of 114,286.66 Pascals to produce the fracture and the other two bodies were hit with a force of 312,448.66 Pascals.

3. Both nasal bones are comminuted, more so on the side of the force. A "C" shape fracture of the bony and cartilaginous septum is found. The fracture begins under the dorsum of the nose and runs posteriorly through the perpendicular plate of the ethmoid, inferiorly through the vomer and terminates with an anterior curve in the cartilaginous septum 1cm above the maxillary crest near the vomerine angle. There is a superior extension through the perpendicular plate of the ethmoid to the base of the skull. The external shape of the nose is noted to be directed to a Grade 3 deviation. Of the six bodies which sustained this fracture, five were males. Two bodies need a force of 66,290.38 Pascals to create this fracture, two bodies required 74,511.60 Pascals and one fracture was made with 50,264.07 Pascals. The frontal force which created this fracture on one cadaver was 312,448.66 Pascals. In the other bodies, the force was lateral.

4. In this type of fracture, the septum is an identical "C" shape fracture as described in type 3 above but the nasal bone involvement in the fracture is noted to be considerably less. The bones were deviated to a Grade 3 deviation. The ipsilateral bone is fractured low and the contralateral bone fractured high, both parallel with the dorsum. Both bodies who sustained this fracture were female. Both noses were hit with 50,264.07 Pascals from the front.

5. In the two bodies hit with great force from a frontal direction, the middle portion of the nasal bone over the dorsum was driven into the nose creating the fracture lines parallel with the dorsum and splaying the remaining nasal bones at the naso-maxillary sutures.

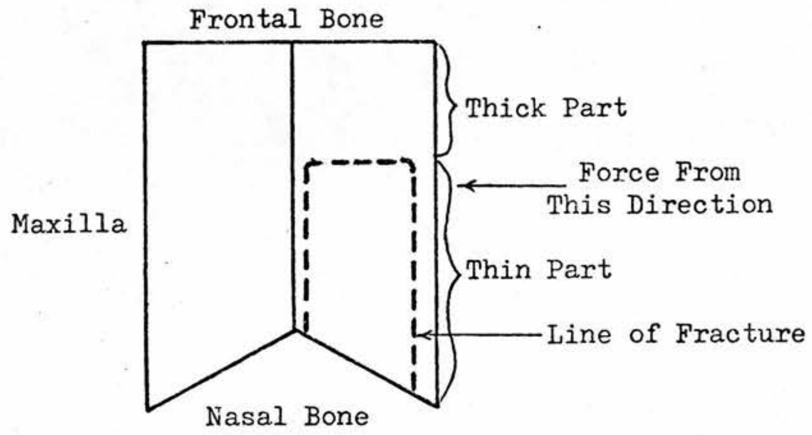
The nasal septum is fractured in the perpendicular plate of the ethmoid. Both required a force of 351,198.00 Pascals, to create this fracture.

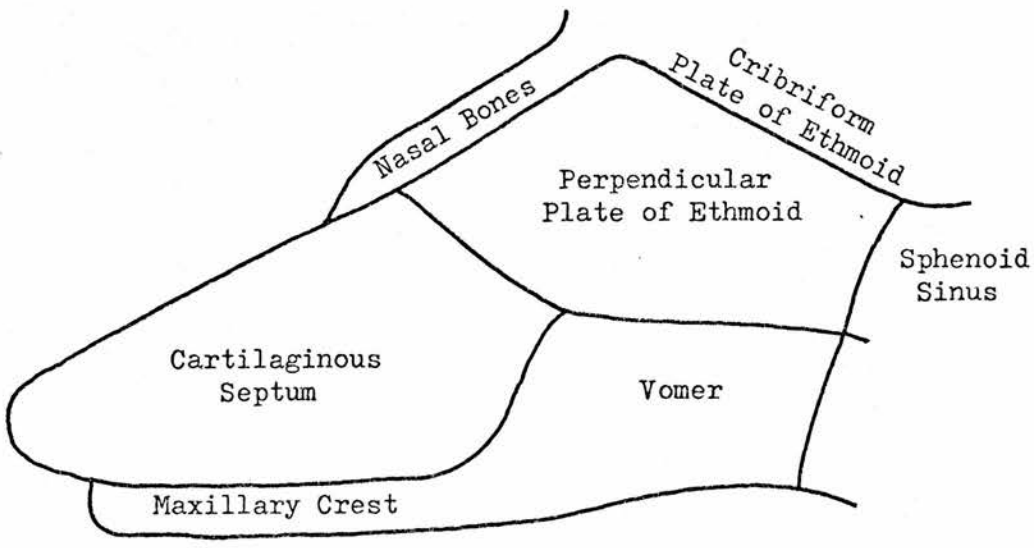
6. This fracture is sustained by a vertical frontal force hitting the cartilaginous dorsum. The cartilaginous septum only is fractured almost parallel to the maxillary crest 1cm above it. The fracture line runs from 0.5cm posterior to the maxillary spine to the junction with the bony septum at the vomerine angle. Five bodies were subjected to this force to create the above fracture. Two bodies required a force of 236,911.33 Pascals and three required 75,537.33 Pascals to create this fracture.

7. This cartilaginous fracture is obtained with a force from an inferoanterolateral direction. The force is directed against the lower end of the nose so that the force is transmitted on to the cartilaginous septum. The fracture line runs from the maxillary spine to the junction of the cartilaginous septum with the perpendicular plate of the ethmoid immediately under the nasal bones. Five bodies were subjected to this force. Unfortunately, the force could not be measured. The angle of the force did not permit the use of the equipment and a surgical hammer was used instead. An impression only, of a lesser degree of force was needed to create this fracture compared with others. It was found, however, that the cartilage did not fracture until the tip of the nose was pushed over almost parallel to the pyriform margin.

It is important to note that manual efforts to shift a Grade 2 deviated nose to a Grade 3 deviated nose and vice versa were unsuccessful unless considerable force was used. The nose always returned to its previous deviation grade.

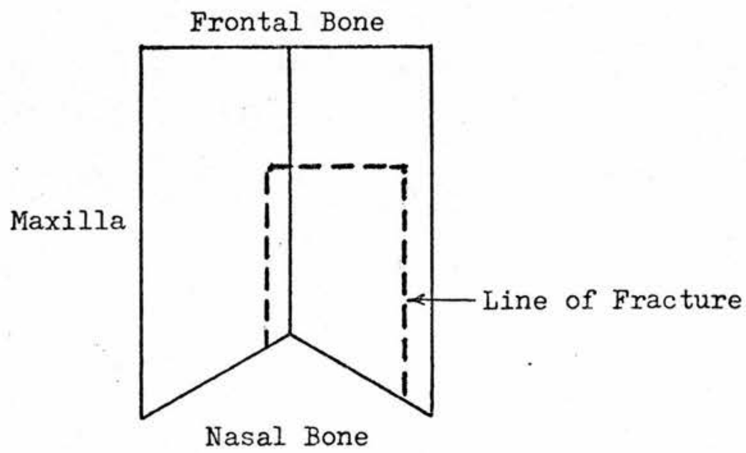
Fig 3.3

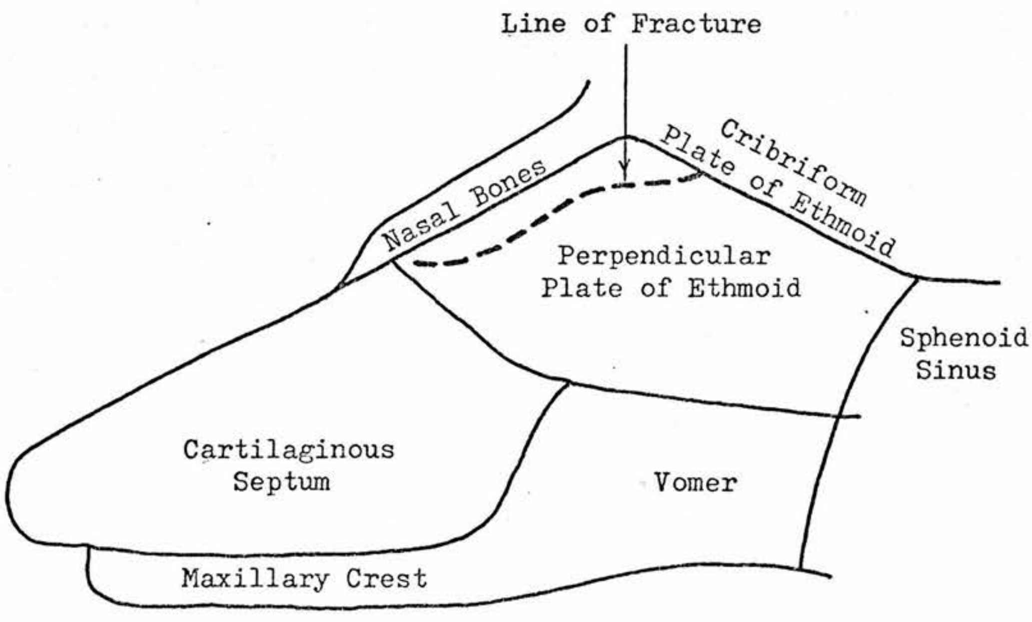




TYPE 1 FRACTURE

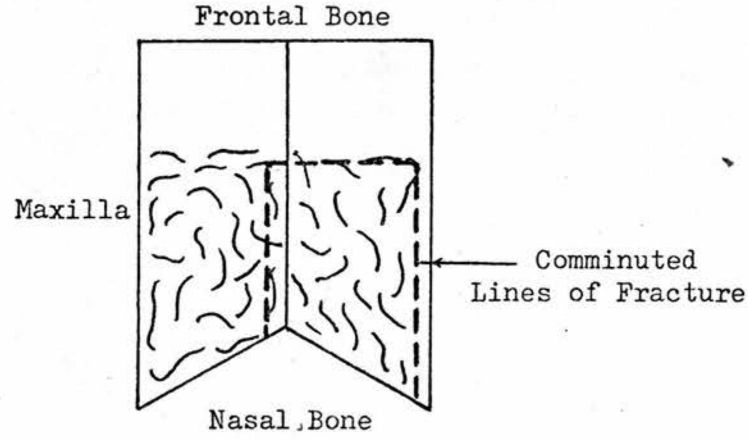
Fig 3.4

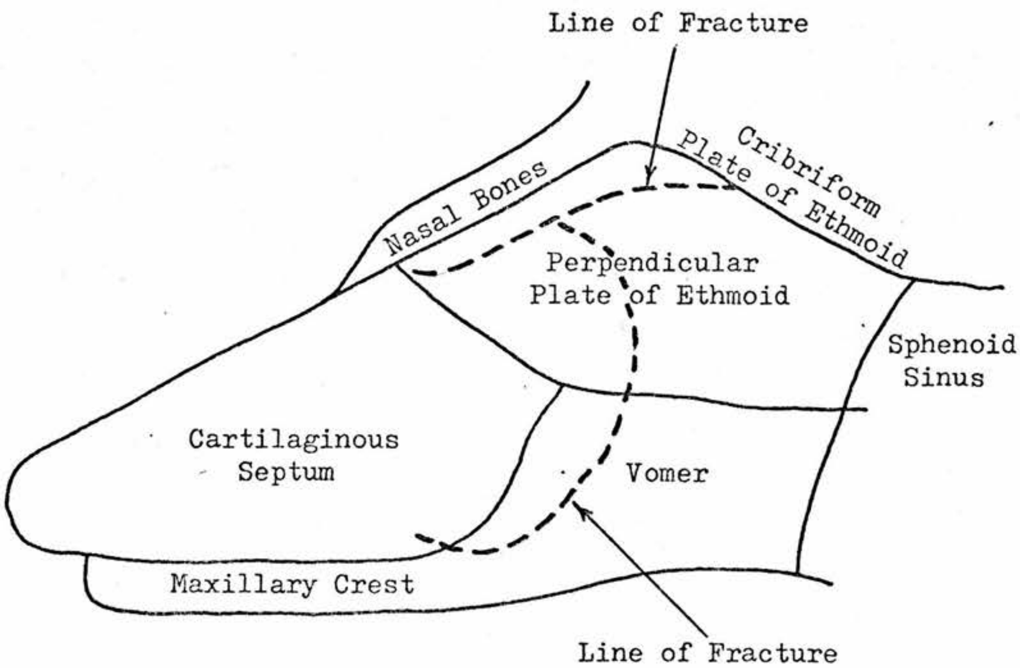




TYPE 2 FRACTURE

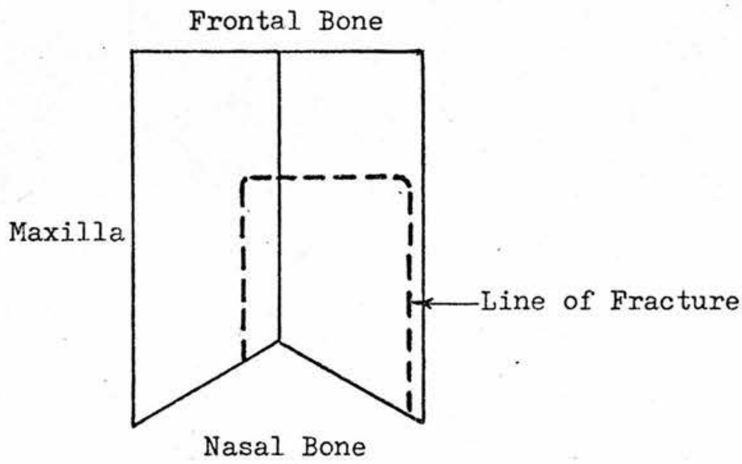
Fig 3.5

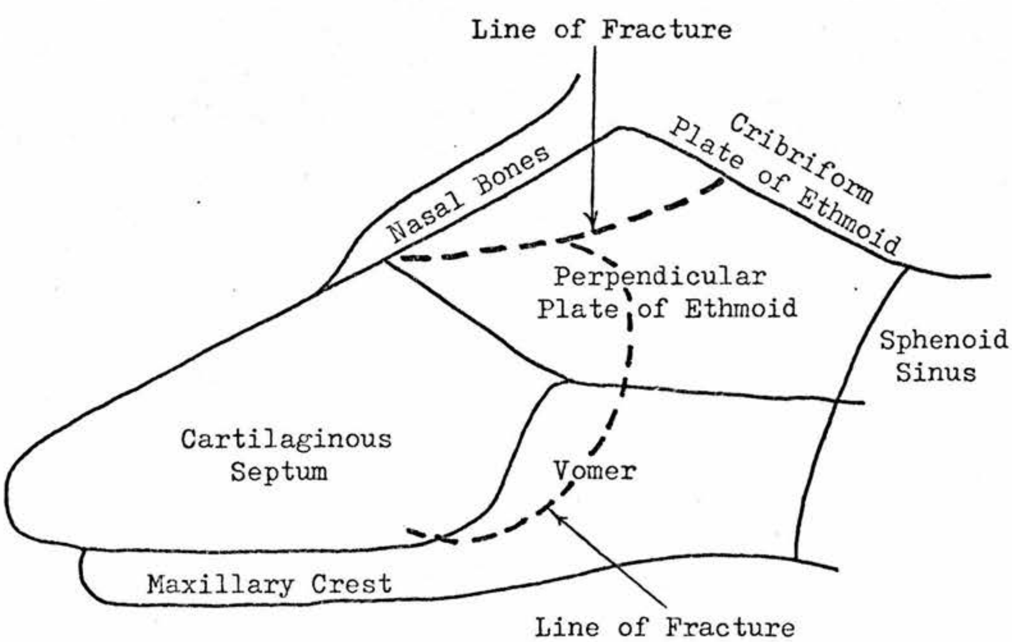




<u>TYPE 3 FRACTURE</u>

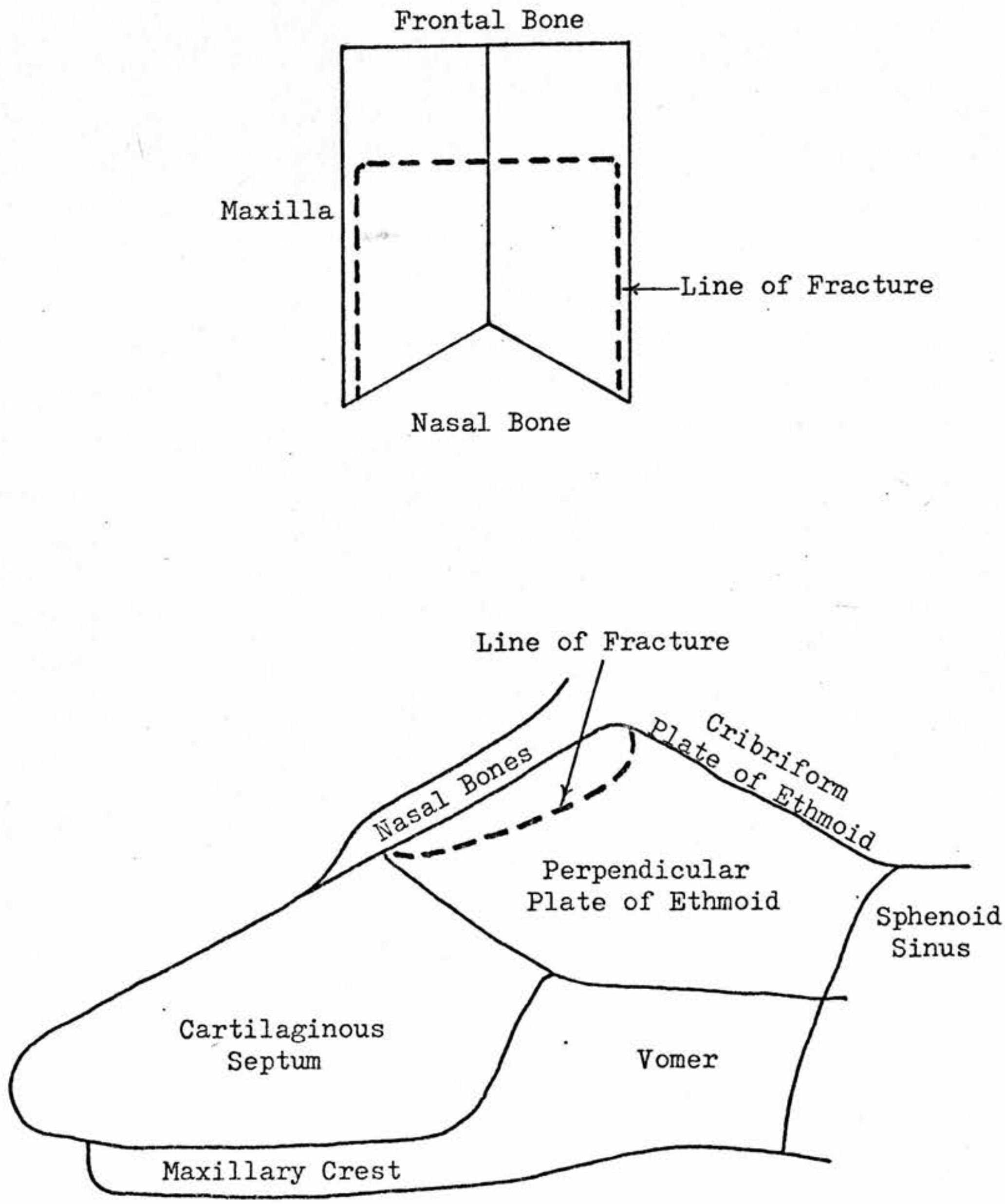
Fig 3.6





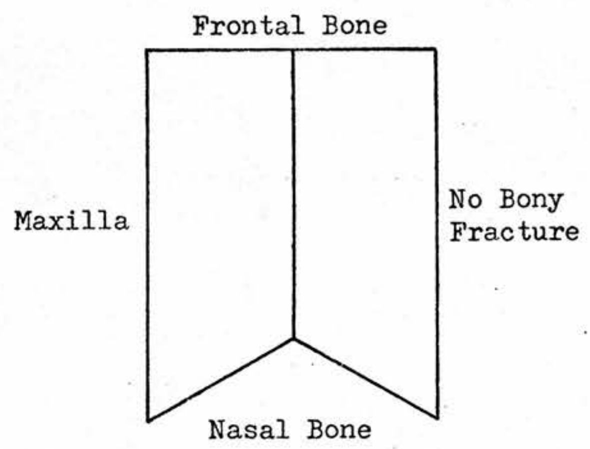
TYPE 4 FRACTURE

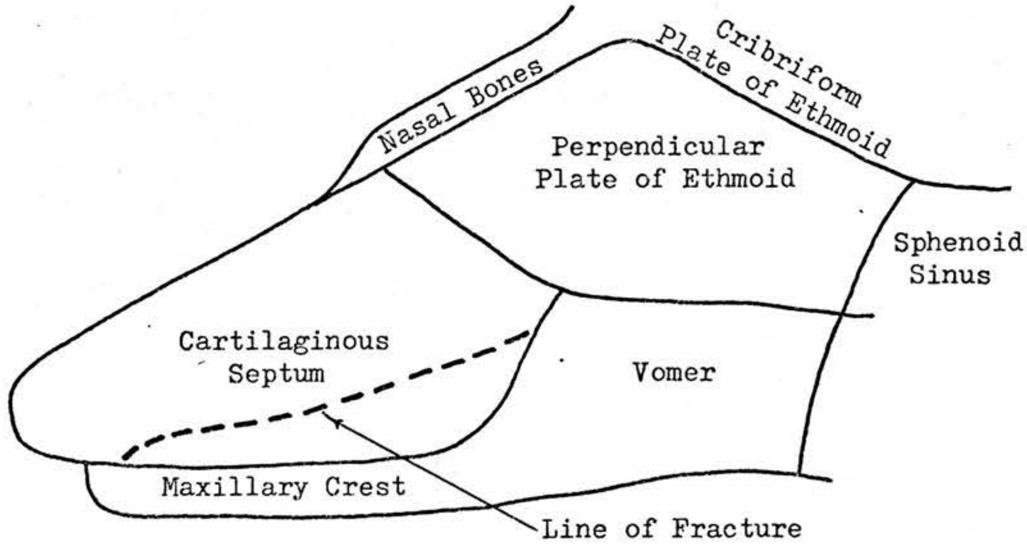
Fig 3.7



TYPE 5 FRACTURE

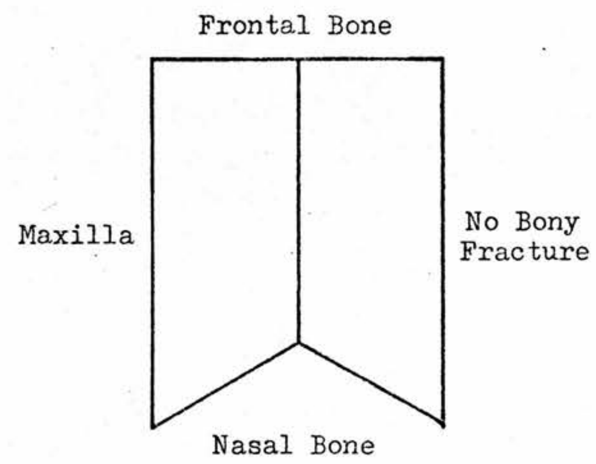
Fig 3.8

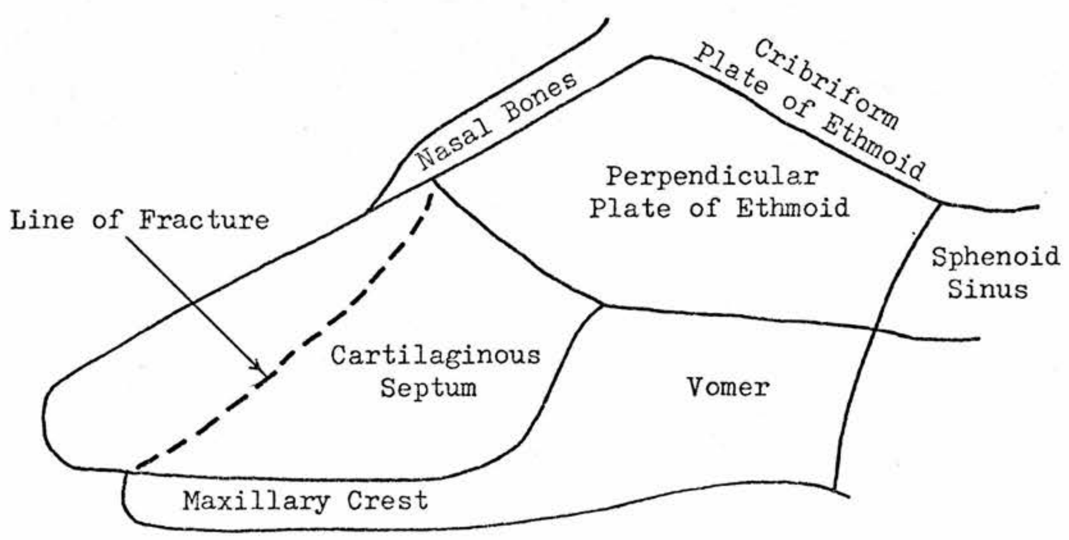




TYPE 6 FRACTURE

Fig 3.9





TYPE 7 FRACTURE

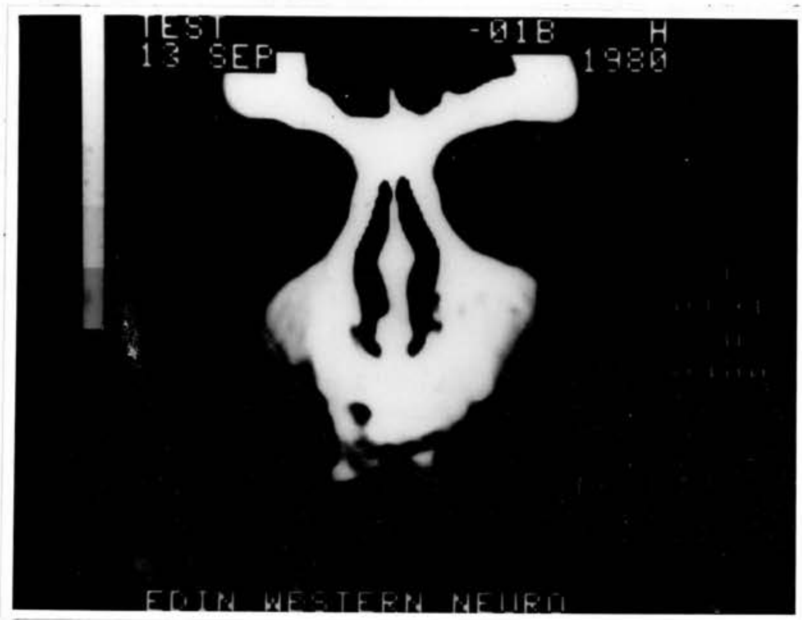
An unembalmed human head was obtained from the Department of Anatomy at the University of Edinburgh. To demonstrate the septal involvement in a nasal fracture, the technique of computerised axial tomography was used. The head, which had a perfectly symmetrical non-deviated external nose and "normal" internal septum was placed in the scanning machine. Vertical "cuts" were taken as represented in Fig: 3.11.

The nose was then hit with a heavy object to fracture the bones. The nose was displaced to a Grade 2 deviation from the midline. The scan was repeated.

The Computerised Axial Tomography scan of the embalmed head is shown in Fig 3.12. The vertical level may be estimated on the head by the presence of the eyelid. The nasal cartilaginous septum is found to be straight.

The initial effort to create a nasal fracture resulted in a Grade 1 deviation from the midline. A C.A.T. scan was performed on the head at this stage but did not show any septal displacement. Following the episode of trauma, the cartilaginous septum would seem to be straight at the eyelid level but a further posterior cut at the level of the perpendicular plate of the ethmoid confirms disruption of the bony septum.

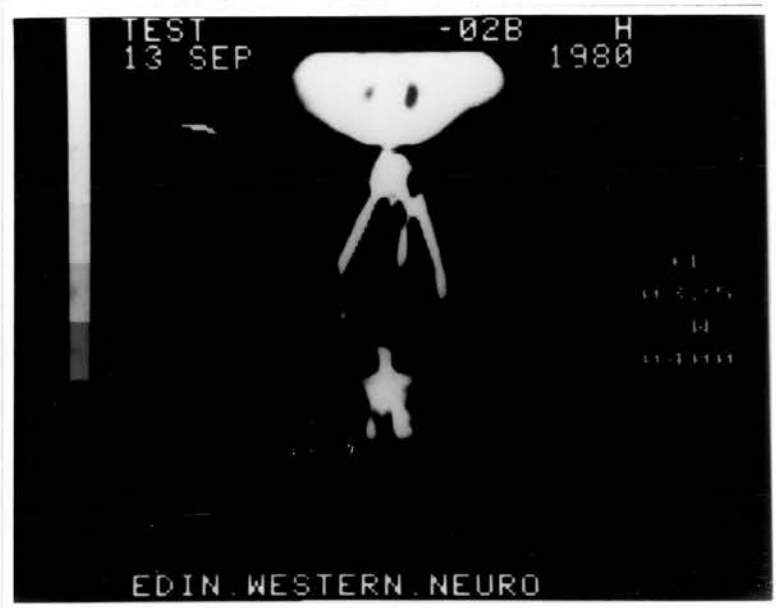
FIG. 3.11.



Vertical C.A.T. Scan of Head Before Trauma

Left Eyelid Shown Dimly.

FIG. 3.12.



Vertical C.A.T. Scans of Head After Trauma.

INACCURACIES OF METHOD.

1. The average age of the cadavers was 71.6 years. The commonest age group to sustain nasal trauma was found to be considerably less. The availability of cadavers of this age group was greatly restricted, the majority being subject to procurator fiscal examination which prevented the use of the body for this experiment.

2. The delivery of a known force on this nose was theoretically easy. In practice, although the dropping of the weight down the pole was almost fractionless, the gauze pad and rubber stopper may well have dissipated some energy. This latter arrangement was made as thin as possible consistent with retaining the integrity of the skin overlying the nose. The head had to be supported during this exercise otherwise it went backwards with the blow. In the clinical situation of course, the head does ride the blow and therefore, any measurements performed in any series are theoretical. The majority of nasal fractures are caused by semi-yielding material e.g. fist, boot, dashboard, even a head to some extent.

This experiment is, therefore, probably more clinically accurate than those of Sturla et al (1980) and Gwyn (1971) who used cold steel to create their fractures.

3. In the C.A.T. scan of the embalmed head, the behaviour of the septum may be influenced by the formalin used to "fix" the head. This adjunct to the main experiment is included merely to underline the importance of the fracture of the perpendicular plate of the ethmoid.

DISCUSSION.

The septum is an integral part of the nose. It is fundamental to correct a malalignment of the septum if one wishes to straighten a broken nose. This influence has been described earlier. Most authors have, however, restricted their thoughts to clinical impression.

Harrison (1979) performed some cadaver experiments to map out the more common lines of fracture. Fifteen cadavers were struck on the nose from varying angles to break the nasal bone with a hammer. The skin was then reflected and four types of fracture were seen. Lateral displacement without septal fracture was caused only by lateral violence. This fracture is identical to the type one found in eight of this author's series.

Harrison's next fracture was that of lateral displacement of the nasal bones with septal fracture. Trauma from both the frontal and lateral aspects caused this fracture. He feels that frontal trauma injures the septum first and the bony pyramid secondarily whereas a lateral blow will fracture the nasal bones first and the septum secondly.

The point of fracture of the septum appears from the diagrams to be near the maxillary crest although this is not clear. This type of fracture corresponds to the 15 fractures in Group 2.

A very important difference of findings occurs here however. In this author's series, the important fracture is that of the septum in the perpendicular plate of the ethmoid whereas Harrison's findings of a low septal fracture were not substantiated. Harrison removed the septum by a submucous resection which does not reach the important area as has already been explained. His method explains his oversight in omitting a description of this high septal fracture which is the most important finding of this experiment. Lack of recognition of this fracture will ensure that a good reduction is not achieved with a simple nasal manipulation which in turn mitigates against a good result. This fracture is only seen clinically, if great efforts are made such as shrinkage of the nasal mucosa and good vision of the area.

In both series, there is agreement on pathogenesis of the fracture of the nasal cap but again, a high septal fracture was found in this series. compared with a low fracture in Harrison's series. There were, unfortunately, only two cases in this series but clinically, this is an uncommon fracture and hence the interest shown in it is limited.

Bridger (1981) recognises the need for double osteotomies in the operation of rhinoplasty. He feels that markedly deviated noses require high and low osteotomies for correction of the bony deformity. These osteotomies trace the high and low fracture lines found in this experiment.

More severe trauma to the nose will undoubtedly damage the septum. This is reflected in both series which agree on the presence of a "C" shape septal fracture. The cartilaginous trauma was performed to ratify those thoughts of Aubry et al (1966). In both series, the fracture of Jarjavay was created by a direct anteroposterior force. The fracture of Chevallet which was the result of infero-superior trauma according to Aubry, was produced in this series by the more common inferoanterolateral direction for nasal trauma.

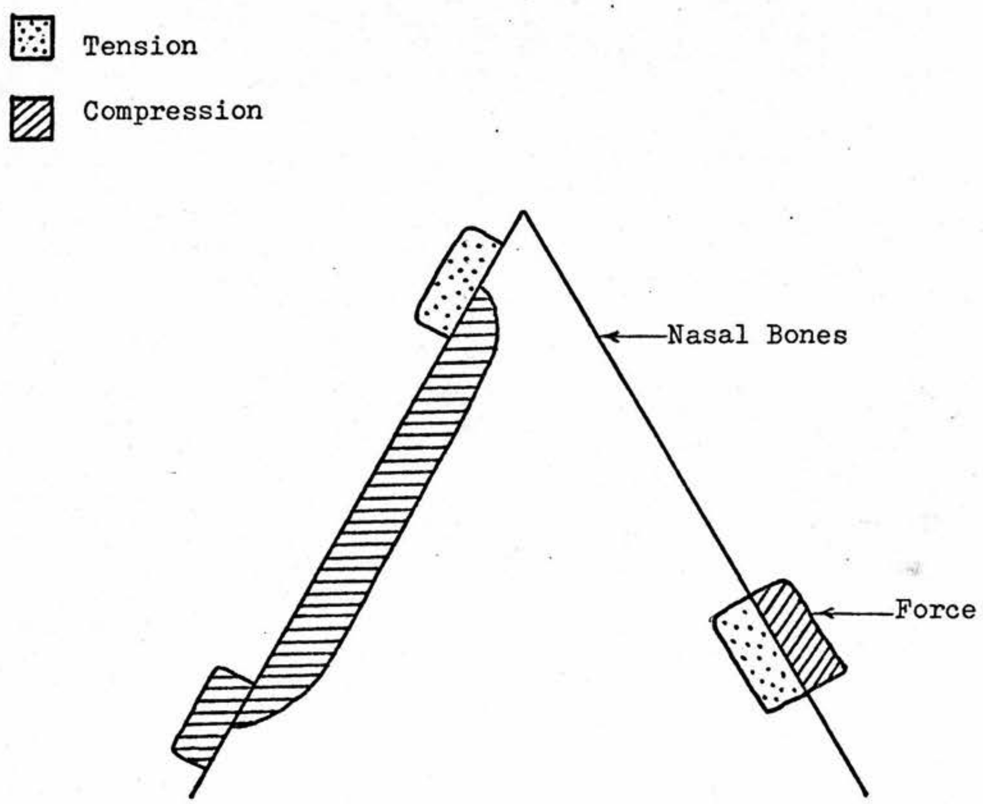
In this series, an anterior direct force sometimes resulted in a lateral deviation. This finding is in keeping with the majority of clinical cases, although one suspects that on seeing a blow about to hit him on the nose, a patient will probably, involuntarily, turn to "ride the blow" while declaring he was hit straight on. Quite severe trauma is necessary to produce a fracture of the nasal cap with a depression of the bones. This fracture was initially ascribed to a glancing blow (Battle 1964) but assuredly, this is incorrect.

The structural problems in the support of the nose were examined by Clark (1967). He described the bony cartilaginous dorsum of the nose as a cantilever. He used dried skull specimens in which he weakened the nasal structure. The specimens were stressed with various weights to determine which structure was the most important in resisting stress. He performed medial and lateral osteotomies, partial excision of the septum posteriorly and inferiorly and total septectomy. The most significant finding was the importance of the area at the root of the nose in maintaining the support of the osseous and cartilaginous portions of the nose.

This area consisted of the nasal spine of the frontal bone, the nasal crest, a strip of the posterior portion of the perpendicular plate of the ethmoid bone and septal cartilage immediately beneath the dorsum. This latter area is similar to that indited by Masing (1965) in his cadaver work. He struck cadavers on the nose with a light hammer and identified fractures of the septal cartilage adjacent to the perpendicular plate of the ethmoid and the upper lateral cartilages. This area is likewise highlighted by this experiment as being of the utmost importance in the fractured nose.

In a subsequent paper, Clark and Wallace (1970) fixed strain gauges on the nasal bones of dried skull specimens. A static stress of weights was loaded on the nose. A force from the opposite side caused the inner aspect of the nasal bone to go into compression and the upper anterior convex part of the bone to go into tension. The outer aspect of the nasal bone low down near the frontal process of the maxilla, however, passed into compression. These findings were less pronounced for a frontal force and even less for a force of the same side. The maximisation of tension and compression forces at the inner aspect and the upper outer convex part of the opposite nasal bone would agree with the finding in this series of the contralateral nasal bone fracture line parallel but immediately below the dorsum Fig 3.10. One must assume direct trauma to the ipsilateral bone causes this fracture. This latter paper describes static stress.

Fig 3.10



CLARK'S FINDINGS IN NASAL BONES SUBJECTED TO A LATERAL FORCE

Clinically, and in the cadaver experiment, the stress is dynamic. Direct measurement of dynamic stress is extremely difficult and involves the use of highly specialised technology. Another method to investigate this is the use of a strain sensitive laquer. This method was introduced by Kuntscher (1934, 1935a,b), who coated a test object with colophonium. It cracked in response to tensile strain or deformation in the underlying materal. The use of such a material to test the distribution of tensile strain in whole bones is well documented (Gurdjian et al 1945, 1946, 1947a and b, 1953, 1961, Evans et al 1948, 1949, 1951, 1952, 1953, De Foret and Ellis 1950). Clark and Wallace (1970) used a similar material to show that the dynamic strain lines were similar to the static experiment. They suggest the groove for the anterior ethmoidal nerve may be a potential site for weakness.

The degree of violence necessary to create a nasal fracture has, hitherto, not been documented. It is extremely difficult to produce a figure which can be repeatedly substantiated as some noses eg, thick, fat noses appear to be stronger than others eg, long thin noses. Also, any wasting disease may affect the strength of the nose. This includes osteoperosis which is almost the normal finding in the age group tested in this experiment.

A mechanical method of creating cranial facial fractures with known forces has been described previously. (Sturla et al 1980, Gwyn 1971). It appears that a force of 25,000 Pascals was necessary to create one or more facial fractures on an autopsy specimen. The authors comment that the nasal complex was completely deranged with this degree of force. These figures are at variance with this author's series.

There can only be one of three explanations. One or other of the experimental designs is inaccurate. It is admitted that a gauze swab was interposed and a rubber stopper at the end of the pole in this experiment. This structure may have dissipated the force a little but unfortunately, this arrangement was a necessary part of the procedure to avoid skin damage. Another explanation may be that the cadavers used had bones of dissimilar strengths. This is unlikely. The most likely explanation is that the computed force on the area under pressure is inaccurate. The area involved in creating craniofacial damage is considerably greater than on the nose. At the moment of impact on the nose, the area under pressure is relatively small and hence the forces at this time are huge compared with the pressure on the middle third of the face as a whole. This would concur with the picture shown in the articles quoted.

Although many authors have stated that the septum is involved if the nose is grossly deviated following nasal trauma, quantification and physical proof have, up until now, been lacking. This experiment shows that if the nose is deviated, more than one half a nose width from the midline then the bony septum is involved. Unless cognisance is taken of this fact and dealt with at operation, the nose is likely to deform again if merely manipulated.

CONCLUSIONS.

1. The nasal pyramidal complex fractures in a characteristic manner.

2. The fractures obtained depend on a variety of variables.

3. These variables include the strength of the nose and the degree and direction of force used.

4. The septum is integrally related to nasal fractures if the nose is deviated more than one half a nose breadth from its original position.

5. Unless the septal fracture is dealt with, the bones will redeviate after a simple nasal manipulation.

TABLE 3.1

Age.	Sex.	Direction of Force.	Used Weight	Type of Fracture	Comments
82	M	LAT	1540	1	
75	F	LAT	4830	1	A greenstick fracture of the perpendicular plate of the ethmoid was found, a spur was created at the vomerine angle.
84	F	LAT	4830	1	
73	M	LAT	4830	1	
75	F	LAT	4830	1	
65	F	LAT	2330	1	
70	M	LAT	4830	1	
73	F	LAT	1540	1	

LAT - Lateral.

FRO - Frontal.

TABLE 3.2.

Age.	Sex.	Direction of Force	Used Weight	Type of Fracture	Comments
73	M	LAT	1540	2	
64	F	LAT	1540	2	The fracture line of the septum extended further inferiorly into the bony septum but did not extend into the vomer.
84	F	LAT	4830	2	
73	M	LAT	6370	2	
65	F	FRO	2330	2	
75	F	LAT	6370	2	
70	F	FRO	2330	2	
84	F	FRO	6370	2	
84	F	LAT	4830	2	
63	F	FRO	6370	2	
70	M	LAT	4830	2	
72	M	LAT	4830	2	

LAT - Lateral.

FRO - Frontal.

TABLE 3.2. (Contd).

Age.	Sex.	Direction of Force	Used Weight	Type of Fracture	Comments.
73	F	LAT	4830	2	
68	M	LAT	4830	2	
59	M	LAT	4830	2	

TABLE 3.3.

75	M	LAT	6370	3	
59	M	LAT	7160	3	
65	M	LAT	4830	3	
61	M	FRO	6370	3	
65	M	LAT	6370	3	
75	F	LAT	7160	3	

LAT - Lateral

FRO - Frontal

TABLE 3.4

Age.	Sex.	Direction of Force.	Used Weight	Type of Fracture	Comments.
78	F	FRO	4830	4	
75	F	FRO	4830	4	A spur appeared at the vomerine angle.

TABLE 3.5

85	M	FRO	7160	5	
79	F	FRO	7160	5	

TABLE 3.6

85	M	FRO	1540	6	
73	M	FRO	4830	6	
79	F	FRO	1540	6	
54	M	FRO	4830	6	
67	F	FRO	1540	6	

LAT - Lateral

FRO - Frontal

TABLE 3.7.

Age.	Sex.	Direction of Force.	Used Weight	Type of Fracture	Comments
85	M	Inferoantero Lateral	Hammer	7	
63	F	Inferoantero Lateral	Hammer	7	
64	F	Inferoantero Lateral	Hammer	7	
81	M	Lateral	Hammer	7	
83	M	Lateral	Hammer	7	

TABLE 3.8.

84	F	Control	No Fracture.
75	M	Control	No Fracture.
59	M	Control	No Fracture.
65	F	Control	No Fracture.
67	M	Control	No Fracture.
53	F	Control	No Fracture.
75	F	Control	No Fracture.

CHAPTER 4.

THE EFFECT OF STRESS ON THE NOSE.

The influence of the septum in the strength of the nasal pyramid has been emphasised by many authors (Garel 1913, Riggs 1953, Rubinstein 1956, Luongo et al 1958).

Clark (1971) demonstrated the importance of the central strut in the resistance of a force in a triradiate structure. A plastic model with photoelastic properties was used through which was shone polarized light. The change in strain was seen with increased loading. The strength of the structure was very dependent on the central member. In another paper (Clark and Wallace 1970), Clark showed with a mathematical model that the shorter and thicker the septum or the wider the nose, the greater is the function of the load bone by the septum. He used two dry skulls and placed strain gauges on the septum and nasal bones. The nose was stressed with static weights. The load taken by the septum in one skull was 62% and in the other 8%.

Another method to measure the direction of stress distribution was first attributed to Hultkrantz (1898). He believed that the collagen fibres of cartilage adopted a characteristic pattern which resulted from constant stress. To demonstrate this, he punctured the surface of the articular cartilage of the lower end of the femur with a sharp circular awl.

He then stained the holes made with india ink and examined them microscopically. The holes were found to be elongated instead of circular as one would expect. The long axes of these puncture sites were reproduceable on the same joint surface from person to person. These elongations he indicated were a reflection of the predominent alignment of superficial collagen fibres. As collagen is the main tension-resistant fibre in the body, the split line must represent the maximum tensile strain tragectory produced by physiological compression and friction forces at the joint surface.

The most comprehensive experimental study of this split line pattern in cartilage was performed by Pauwels (1959), using a gelatin model of the glenoid cavity of the human shoulder joint and the engineering technique of photoelastic stress analysis. The results tended to agree with the conclusion of Hultkrantz.

This was further confirmed by Kempson et al (1968, 1972) when he tested the tensile strength of articular cartilage parallel to the predominent collagen fibres and at right angles to these fibres. He found the parallel orientated specimens were stiffer and stronger than the perpendicular orientated specimens. These findings, however, only relate to articular cartilage which is, of course, subject to daily external stress. Also, it is closely attached to underlying bone which may have some influence on the distribution of collagen fibres rather than purely the result of stress.

Ilberg (1939) felt this theory could be related to septal cartilage. He punctured a cadaver in the manner of Hulkrantz on the cartilages of the nose and also on the nasal bones.

A mosaic-like distribution of lines was found in the septum. The lines on the vomer ran obliquely backwards from the arch of the hard palate to the body of the sphenoid bone. The perpendicular plate of the ethmoid bone showed vertical lines in its cephalic portion and oblique lines in the more caudal portion.

Ilberg, therefore, felt that the more caudal and anterior part of the perpendicular plate of the ethmoid bone is subject to compressional stresses from above and in front of the region of the upper part of the dorsum of the nose. The vomer was thought not to be subjected to these stresses. The lines of tension found in the nasal bones and lateral cartilages were at random and were not thought to be relevant. The lines of tension found in the perichondrium and periostium were similarly irrelevant.

The arrangement of collagen fibres in the superficial layers of cartilage may not reflect the arrangement in deeper layers. Initially, Gibson and Davies (1958) highlighted the warping of costal cartilage following implantation into the deficient dorsum of a nose. Following this, Fry (1966, 1969b, 1973) in a series of papers which are fully discussed in Chapter 5, felt that there is an internal inter-locked stress system within the septal cartilage. He indicated most definitely the outer layers of cartilage do not reflect the inner part of the sandwich.

The septum does appear to be involved in certain types of nasal fracture. Common sense would indicate the most likely areas affected would be immediately under the deforming force. In Chapter 3, however, it was found that the perpendicular plate of the ethmoid was the most important area fractured in a severely deviated nose. This Chapter uses the photoelastic technique on a model to demonstrate why this should happen.

METHODS AND MATERIALS.

Perspex is a photo-elastic material. If bipolarized light is shone through this substance, natural "stress" lines may be seen. If the material is stressed externally, these lines of force are re-arranged to take up the shape characteristic to that angle and degree of force stressing the material. This is an accepted engineering principle to test the effective stress on different structures.

A perspex model of the nasal septum was made. The cartilaginous septum was represented by a straight piece of perspex of 0.25cm uniform thickness and the bony septum was of 0.3cm uniform thickness. The different thicknesses of the bony and cartilaginous septums represent the relative strengths of these materials. Both were measured in the four corners of the shape and in the middle on three separate occasions using outside measuring Vernier calipers. Each time, the measurements were identical. The height of the whole model was 8.2cm, the length of the bony septum was 8.5cm, the height of the cartilaginous septum was 6.1cm and the length was 9.7cm. The average shape of the bony cartilaginous junction was reproduced from various anatomical text books and dried skull specimens.

However, to ensure there was no undue influence on the results of this experiment because of the variability of the bony/cartilaginous junction, three such perspex models were prepared. In one, Model A, the angle of the junction under the root of the nose was (angle 1) 94°, the vomerine angle (angle 2) was 269° and the angle from the vomer to the maxillary crest (angle 3) was 65°. Model B had the angles as follows: 1. 100° 2. 92° 3. 147°. Model C had the angles as follows: 1. 85° 2. 90° 3. 144°.

In Model A, the distance of the cartilaginous septum under the nasal bones was 3.05cm. In Model B, it was 2.30cm and in Model C, it was 2.75cm. A weight was placed on the area where the nasal bones joined the septum. The angle of the weight was varied from 90° to 135° to 180° to the septum. The area under the weight on the dorsum again varied from model to model. In Model A, this area was 2.67cm by 0.3cm. In Model B, this was 2.20cm by 0.3cm and in Model C, this was 2.65cm by 0.3cm.

The Model was viewed through the polarized light apparatus to identify the change in the stress lines. In any structure there are lines of stress present reflecting the influence of one material abutting another, particularly in this case where the cartilaginous septum is surrounded on more than two sides by the bony septum. Hence, stress lines form naturally around the bony cartilaginous junction on these models with the absence of extraneous stresses. These are built into the model when being made. It is, therefore, the change in these stress lines with the addition of the extraneous force which is recorded. This may be manifest using normal white light as either dark or light areas. Both shades indicate a change in the speed of light through the perspex and are an accurate method of recording the change in the lines of stress. This again was repeated on three separate occasions with repeated accuracy to exclude errors.

The area of change in the stress lines was then outlined on the perspex with a felt-tip pen. The areas of "high stress" that is, those areas which showed a marked change in pattern, were circumscribed with red and those areas with "low stress" were outlined in green.

Previously, an exact copy of the perspex shape and measurements had been detailed on 5mm graph paper. The graph paper was overlaid the perspex model, seen to fit and the felt-tip markings which could be easily seen through the paper were transcribed. The area under stress was measured by counting the 5mm squares under stress. If the line crossed or touched the square, this was counted as a whole square.

The weights used were the same as used in the experiment described in Chapter 3.

A correlation was then made between the various weights placed on the dorsum i.e. forces and the areas of high and low stress. An identical method was used to apply stress to solely the cartilaginous dorsum from a vertical and lateral direction. The lateral weight was only placed on the tip of the septum to represent a blow from the side i.e. the area of the septum not protected by the nasal bones. All of the measurements were repeated on three entirely separate occasions to ensure completely accurate and repeatable observations.

RESULTS.

An idea of the distribution of the high and low stress areas may be gained from the diagrams in Figs. 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15, (which are not to scale).

Table 4.1, however, shows the actual number of squares included in the high and low stress areas of the various models. Figs. 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15 are included merely to gain some idea of the relative areas under strain with varying degrees of stress.

The models with the weights on the nasal bones were subjected to a variation in the angle of force i.e. the weights were placed at 90°, 135° and 180° to the septum. This variation in angle surprisingly did not affect the area under strain and the results were identical whatever the angle of stress.

For Model A, the low pressure area had a poor correlation with the weight and therefore, the force applied i.e.

$$r = 0.2552 \qquad r^2 = 0.065127 \qquad t = 0.4572$$

$$3 \text{ D.F.} \qquad P > 0.5$$

The high pressure area, however, correlated well in that:-

$$r = 0.9553 \qquad r^2 = 0.912598 \qquad t = 5.5969$$

$$3 \text{ D.F.} \qquad 0.02 > P > 0.01$$

The regression equation of this is:-

$$y = 1.77 + 0.0271 X \qquad \text{(See Fig 4.16).}$$

Model B gave a better correlation for both the high and low pressure areas. The high pressure areas give the following results:-

$$r = 0.9497 \qquad r^2 = 0.90193 \qquad t = 5.2518$$

$$3 \text{ D.F.} \qquad 0.02 > P > 0.01$$

For the low pressure areas, the results were as follows:-

$$r = 0.957 \qquad r^2 = 0.9158 \qquad t = 5.7124$$

$$3 \text{ D.F.} \qquad 0.02 > P > 0.01$$

The regression equation for the high pressure area is:-

$$y = 1.36 + 0.0316 X \qquad \text{(See Fig 4.17)}$$

For the low pressure area, the regression equation is:-

$$y = 2.245 + 0.0272 X \qquad \text{(See Fig 4.18).}$$

In Model C, the results of the high pressure are very significant but that of the low pressure equivocal.

High Pressure:

$$r = 0.9762 \qquad r^2 = 0.953 \qquad t = 7.79$$

$$3 \text{ D.F.} \qquad 0.01 > P > 0.001$$

$$y = 0.32 + 0.0253\,X. \qquad \text{(See Fig 4.19)}$$

Low Pressure:

$$r = 0.8882 \qquad r^2 = 0.788992 \quad t = 3.3483$$

$$3 \text{ D.F.} \qquad 0.05 > P > 0.02$$

In all the models, the area of high stress appears constant at the bony cartilaginous junction. There is a small area immediately under the deforming stress which is also apparent. An increase in the force eventually leads to a pressure build-up near the maxillary spine. According to these models, the shape of the bony cartilaginous junction has no effect on the distribution of the strain lines.

The effect of the amount of cartilaginous septum immediately under the nasal bones may also be studied. Table 4.2 demonstrates this numerically. It is assumed in all the models that the weight acts solely on that area of cartilaginous septum immediately under the nasal bones. For Model A, this area was $0.305 \times 0.025m^2$. Model B was $0.23 \times 0.025m^2$. For Model C, $0.275 \times 0.025m^2$.

For Model A, the high pressure correlation is:-

$r = 0.5199 \qquad r^2 = 0.270296$

$t = 1.0542 \qquad 3$ D.F. $\qquad 0.5 > P > 0.1$

For Model B, the high pressure correlation is:-

$r = 0.9521 \qquad r^2 = 0.906$

$t = 5.3787 \qquad 3$ D.F. $\qquad 0.02 > P > 0.01$

For Model C, the high pressure correlation is:-

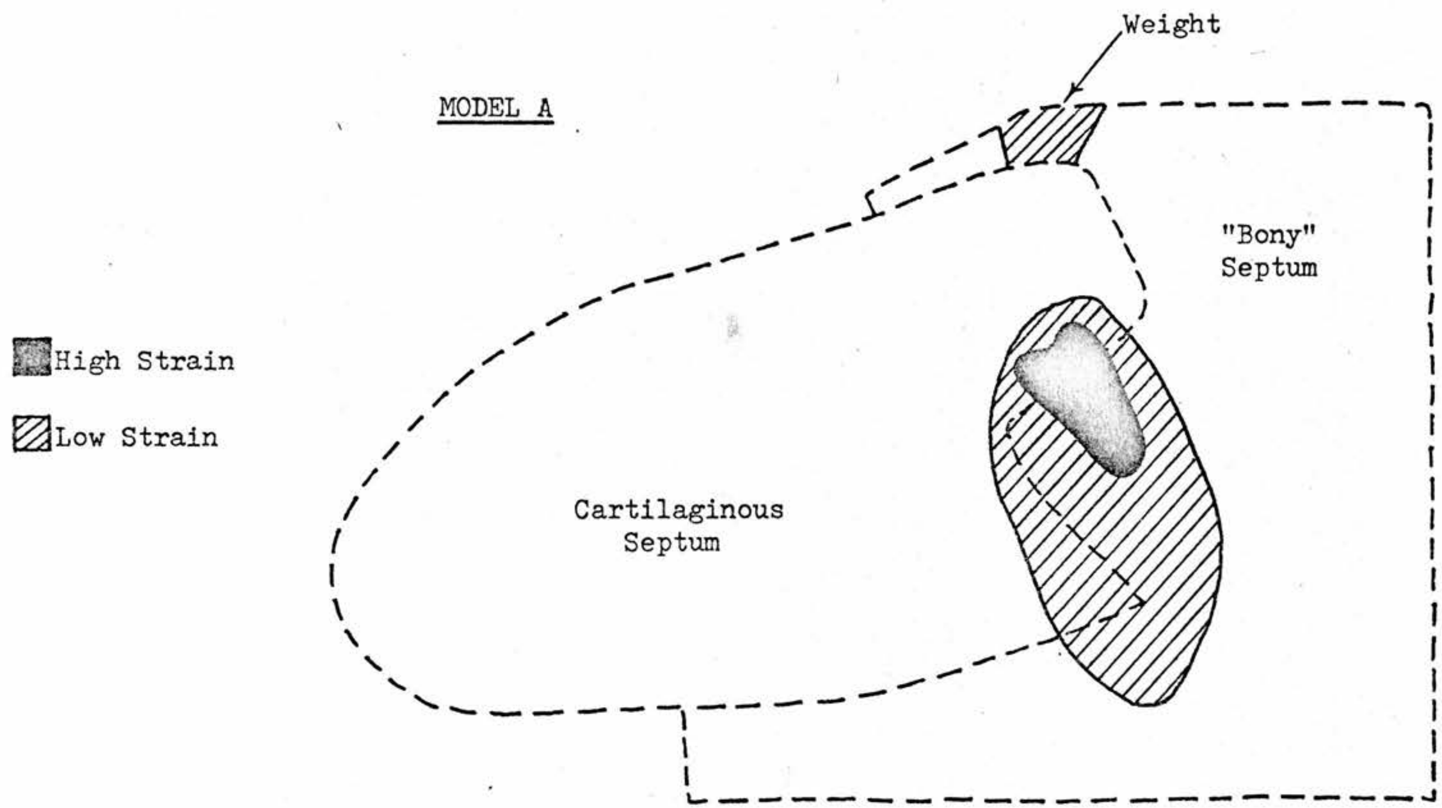
$r = 0.9186 \qquad r^2 = 0.844$

$t = 4.028 \qquad 3$ D.F. $\qquad 0.05 > P > 0.02$

Table 4.3 shows the number of high pressure squares associated with loading the septum either on the cartilaginous dorsum or the lateral tip of the septum. No correlation was attempted in this part of the experiment as no further useful information would be gained. A useful statistical correlation would not be possible using the small numbers of results quoted. Figs. 4.20 4.21 4.22 4.23 4.24 4.25 4.26 4.27 4.28.

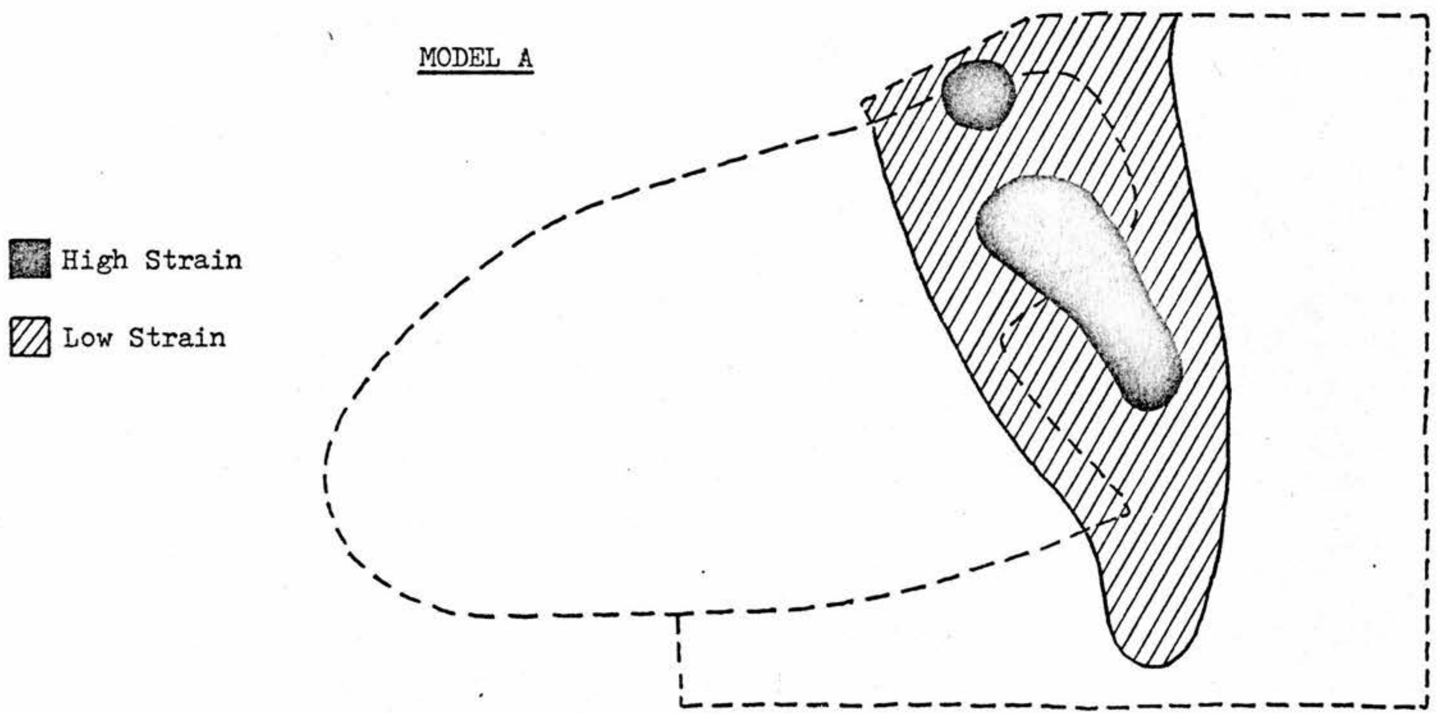
Fig 4.1

MODEL A



WEIGHT OF 1.54 KG ON NASAL BONES

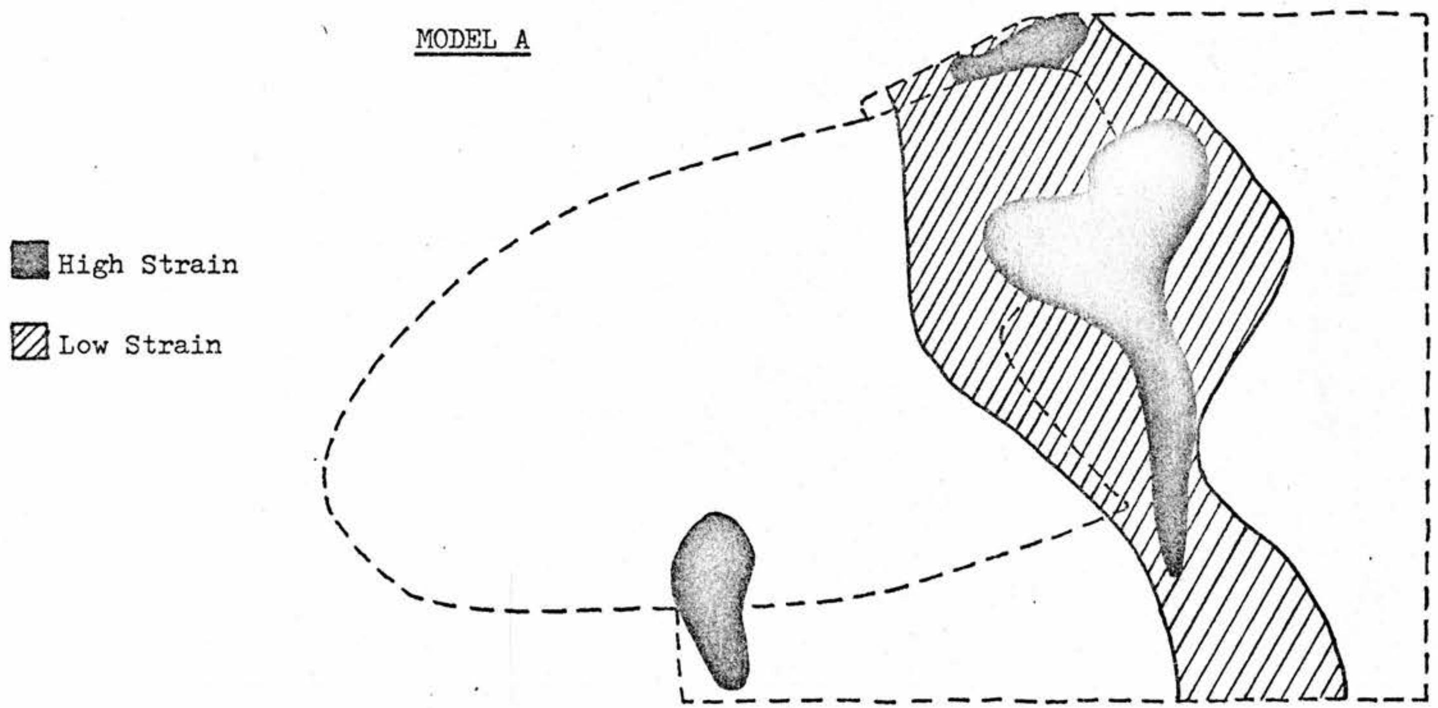
Fig 4.2



WEIGHT OF 2.33 KG ON NASAL BONES

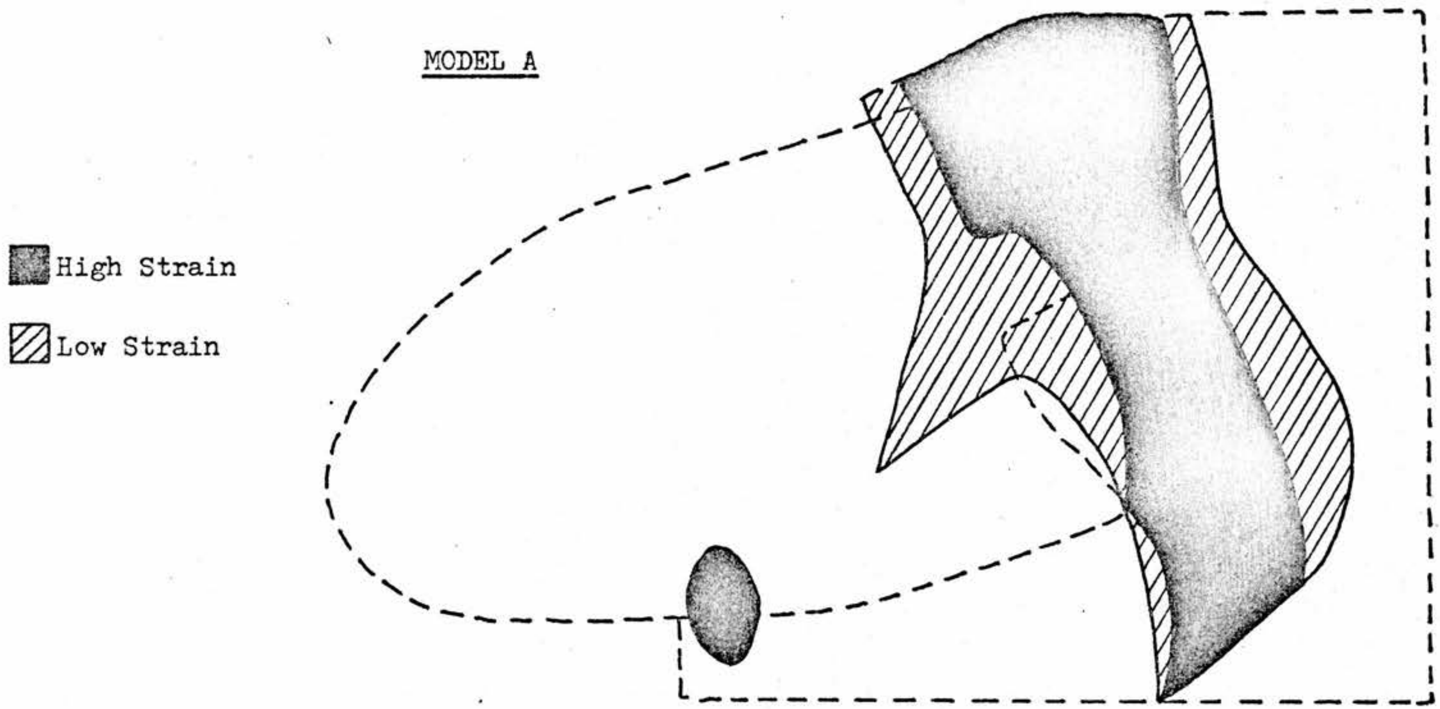
Fig 4.3

MODEL A



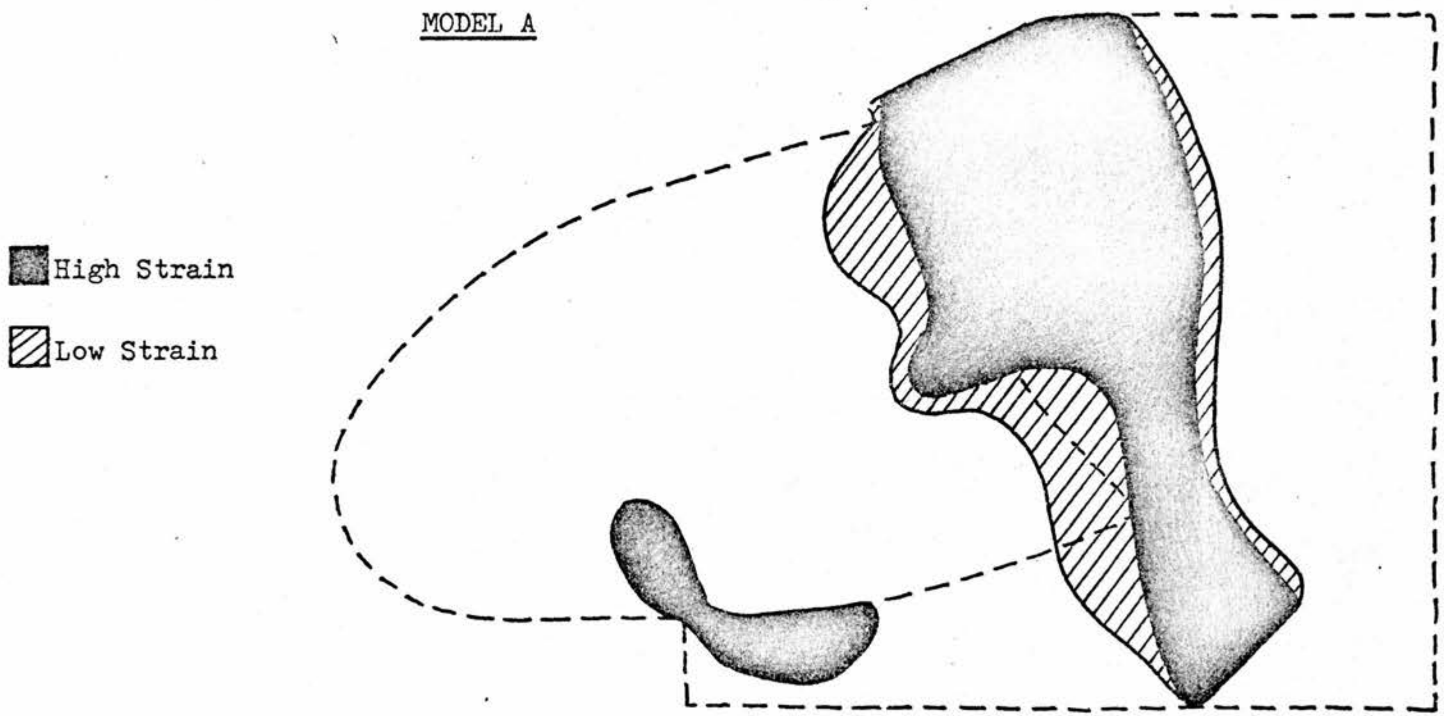
WEIGHT OF 4.83 KG ON NASAL BONES

Fig 4.4



WEIGHT OF 6.37 KG ON NASAL BONES

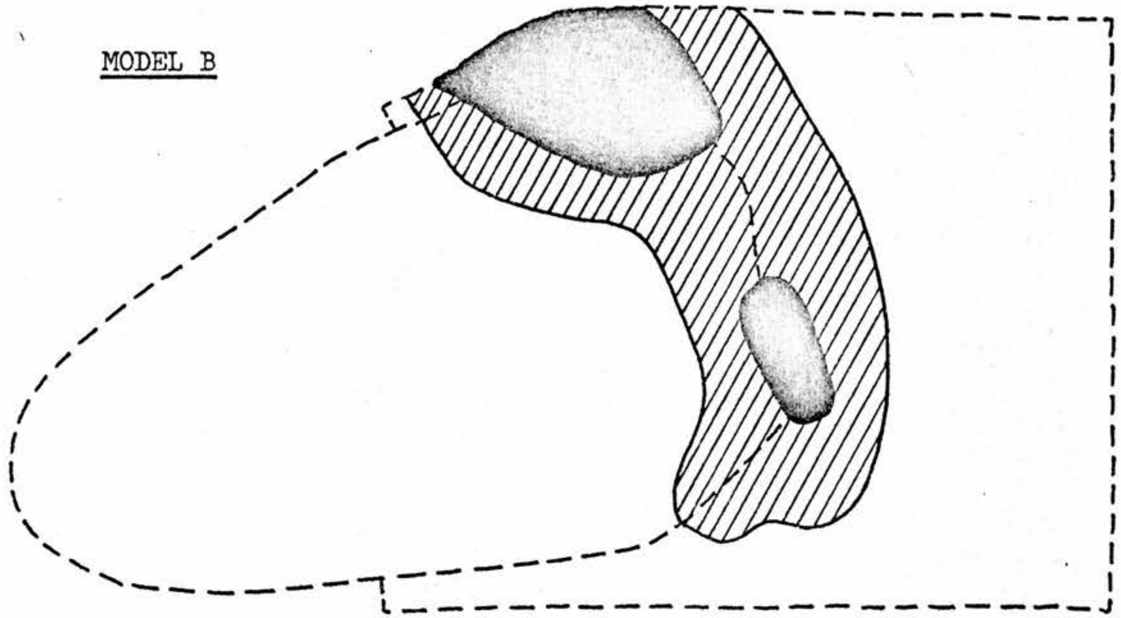
Fig 4.5



WEIGHT OF 7.16 KG ON NASAL BONES

Fig 4.6

MODEL B

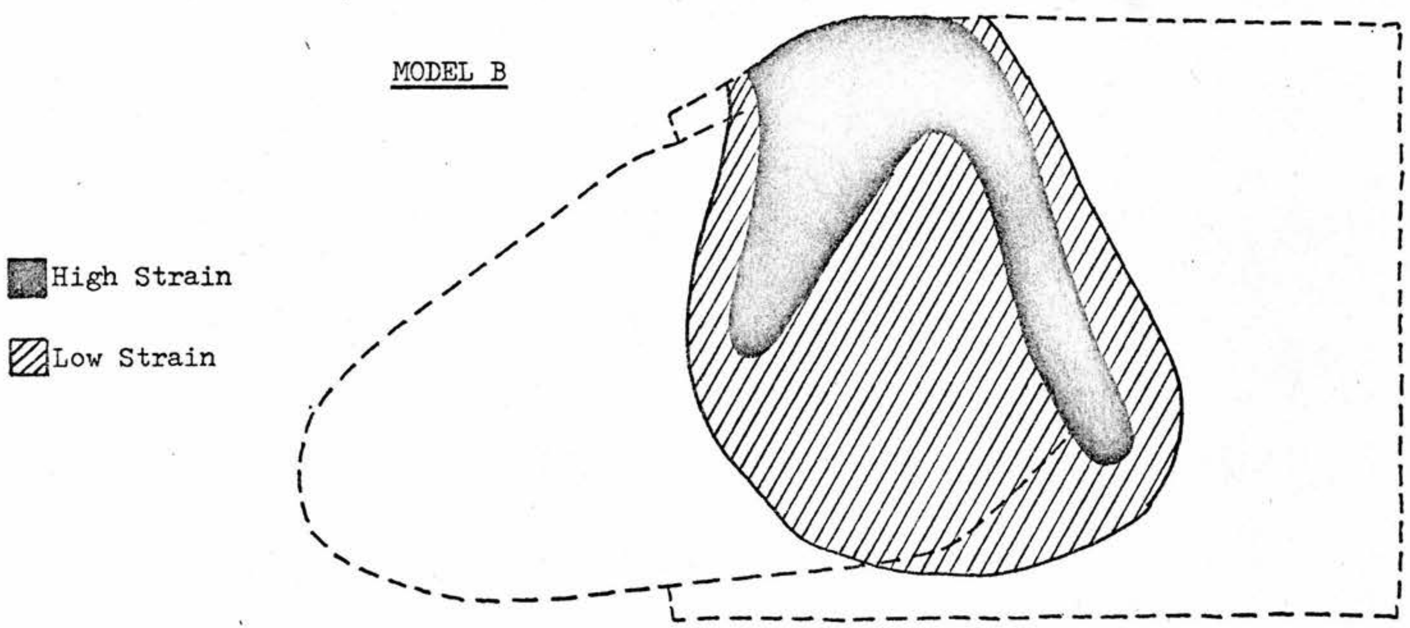


High Strain

Low Strain

WEIGHT OF 1.54 KG ON NASAL BONES

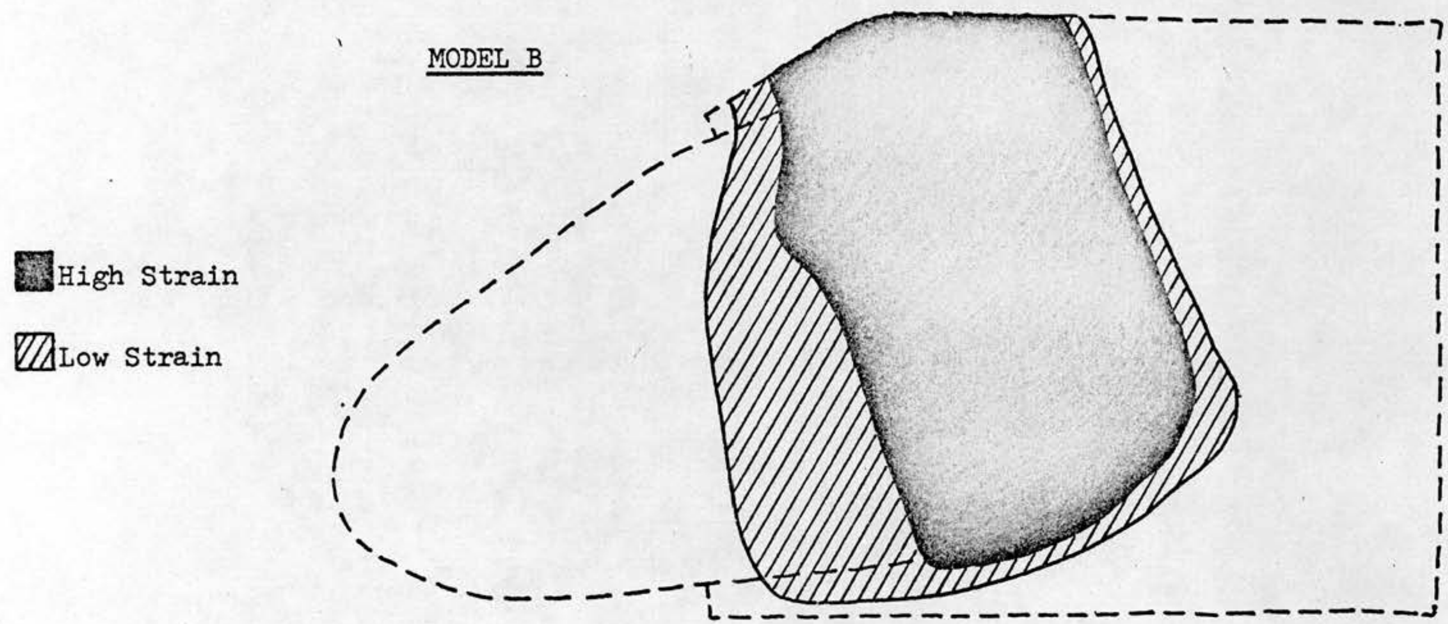
Fig 4.7



WEIGHT OF 2.33 KG ON NASAL BONES

Fig 4.8

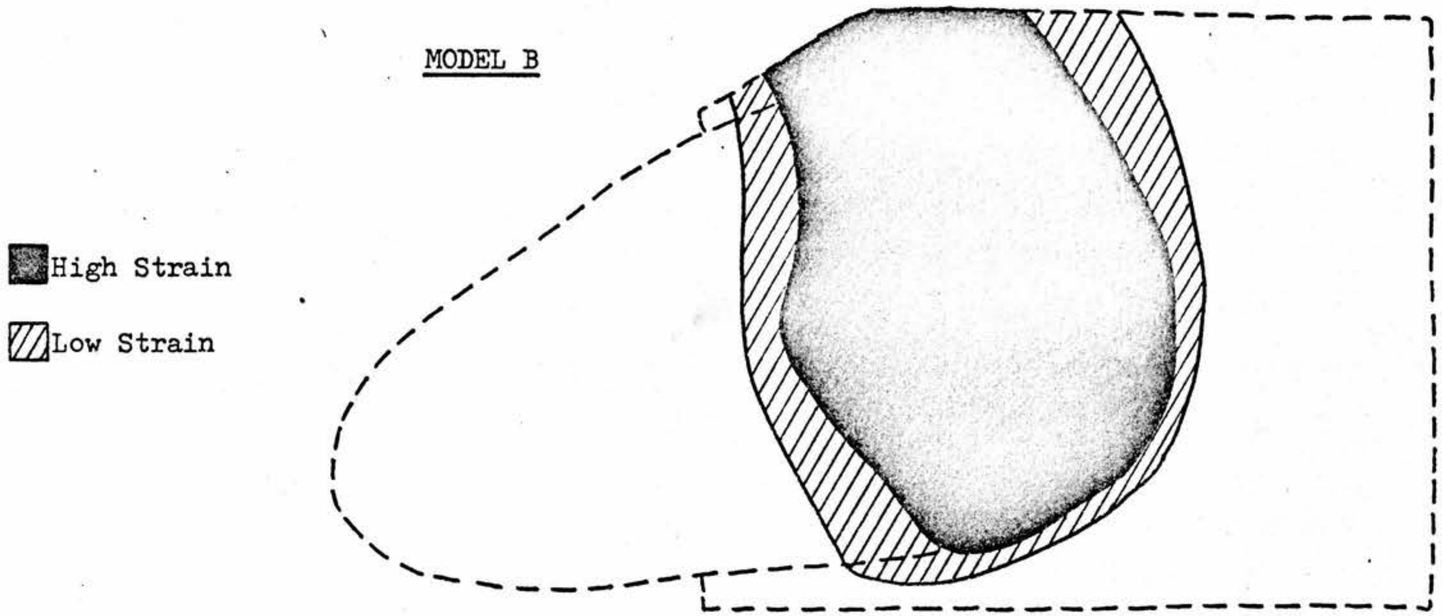
MODEL B



WEIGHT OF 4.83 KG ON NASAL BONES

Fig 4.9

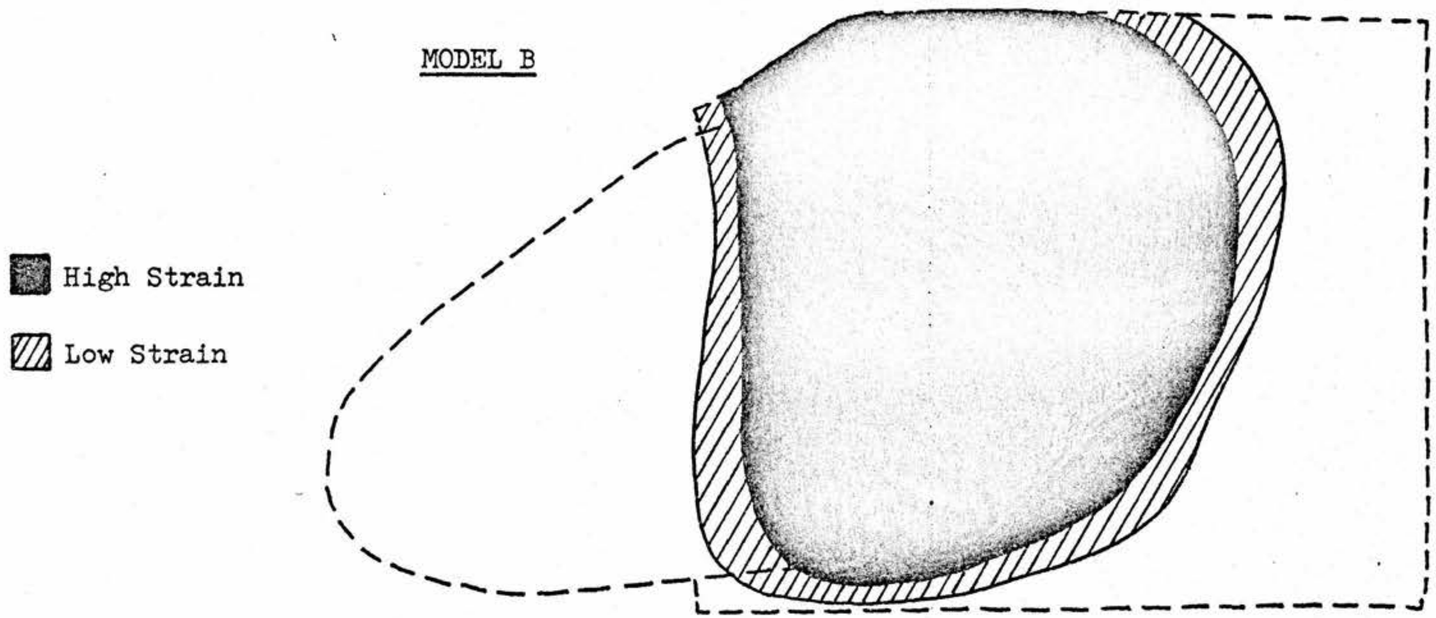
MODEL B



WEIGHT OF 6.37 KG ON NASAL BONES

Fig 4.10

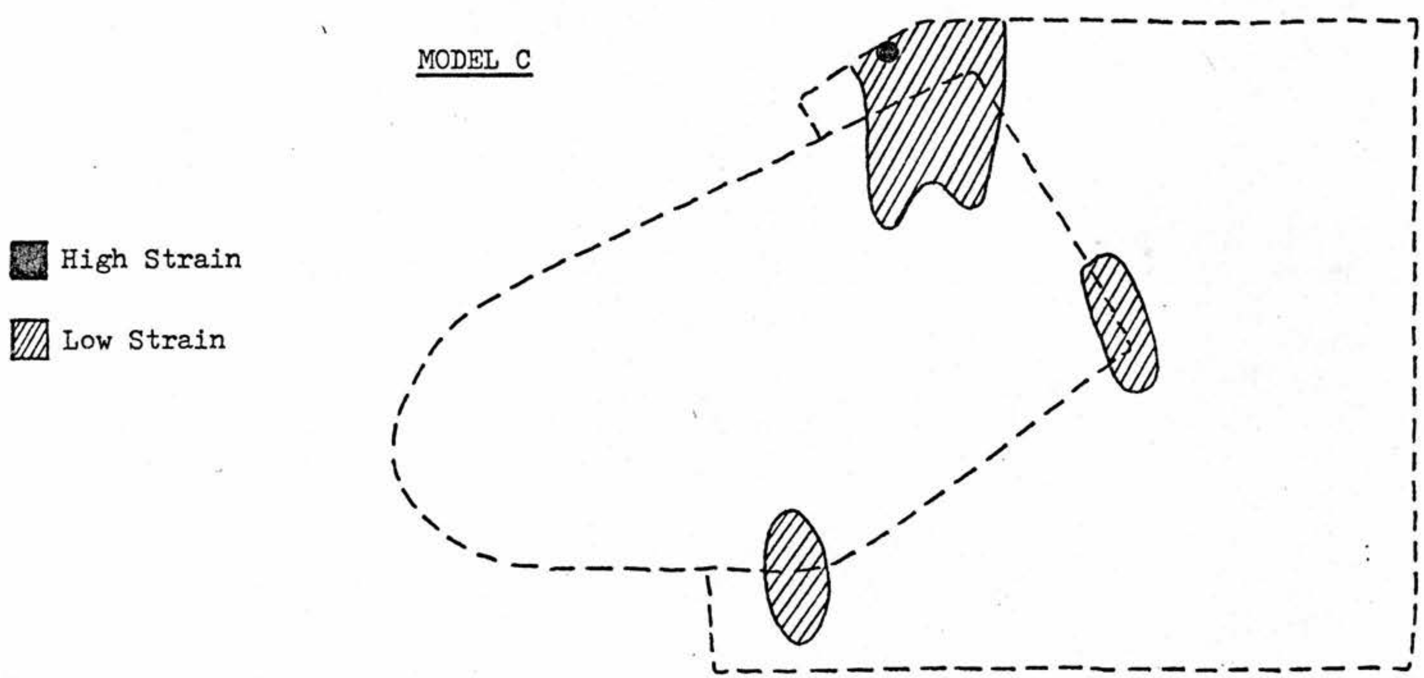
MODEL B



WEIGHT OF 7.16 KG ON NASAL BONES

Fig 4.11

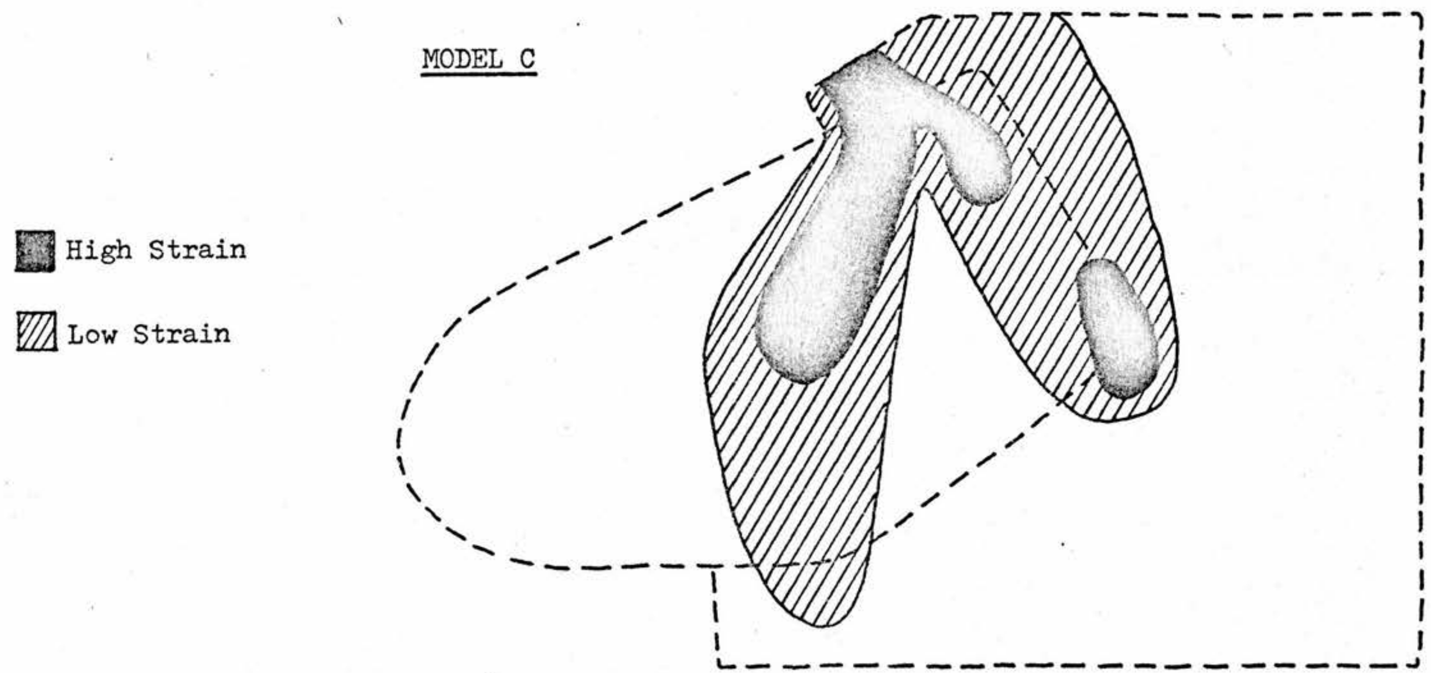
MODEL C



WEIGHT OF 1.54 KG ON NASAL BONES

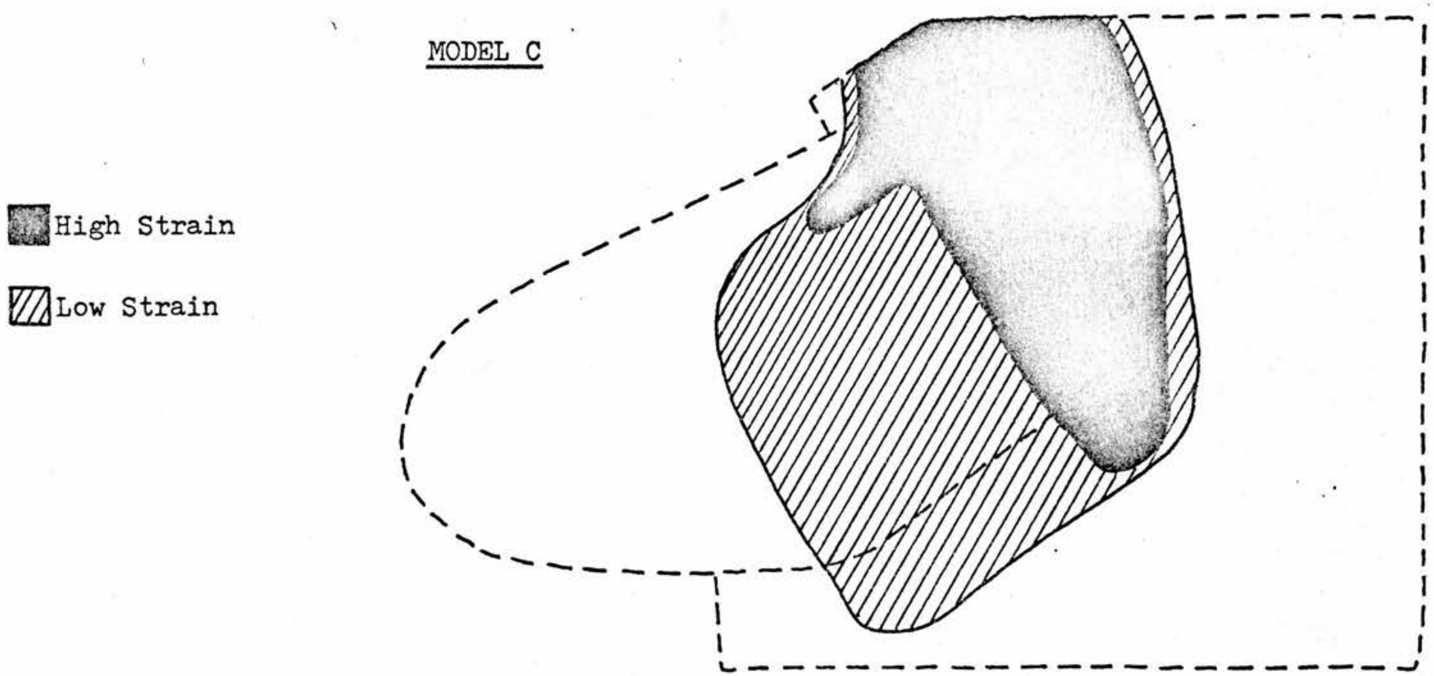
Fig 4.12

MODEL C



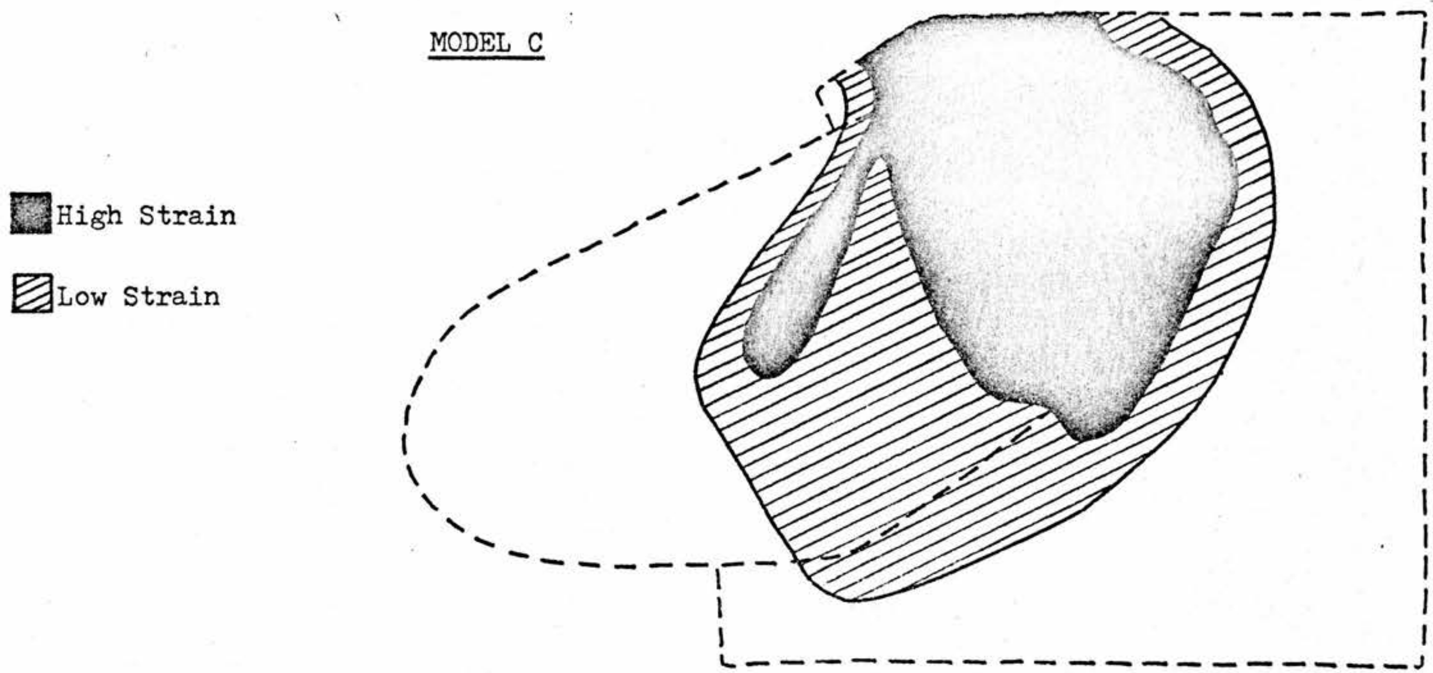
WEIGHT OF 2.33 KG ON NASAL BONES

Fig 4.13



WEIGHT OF 4.83 KG ON NASAL BONES

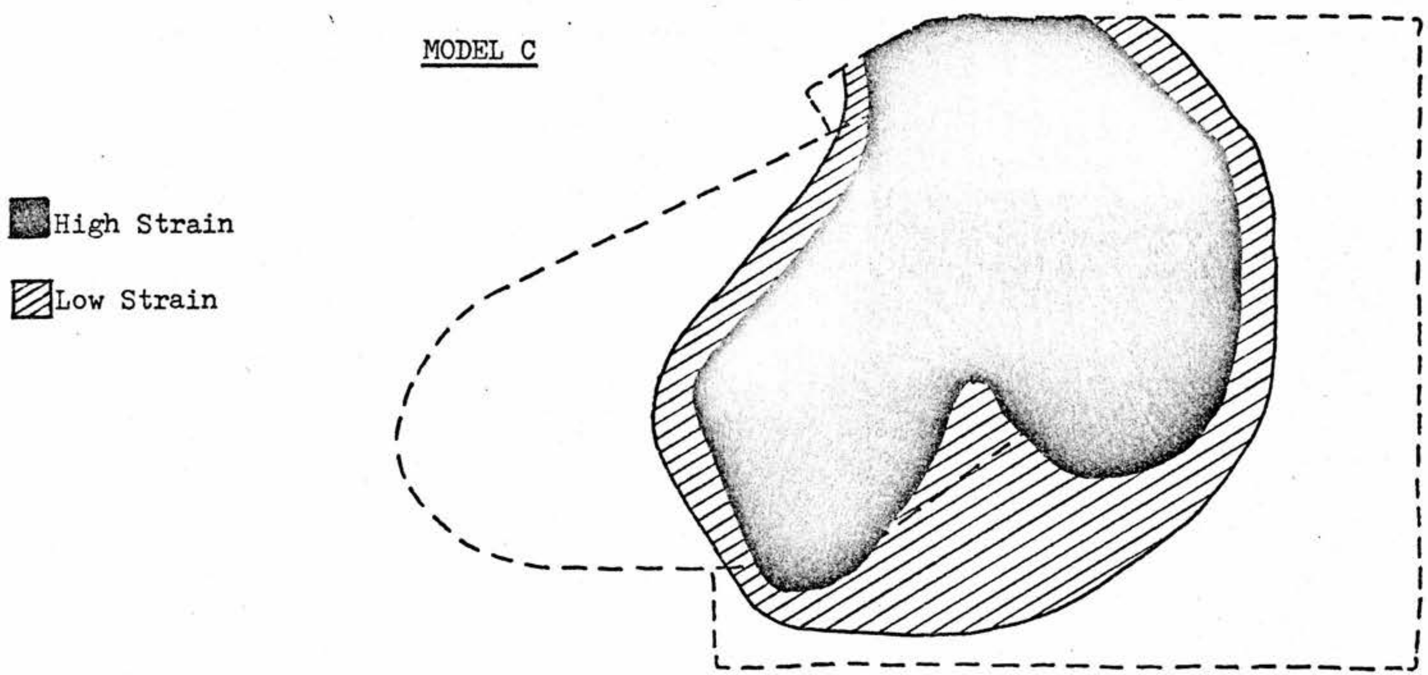
Fig 4.14



WEIGHT OF 6.37 KG ON NASAL BONES

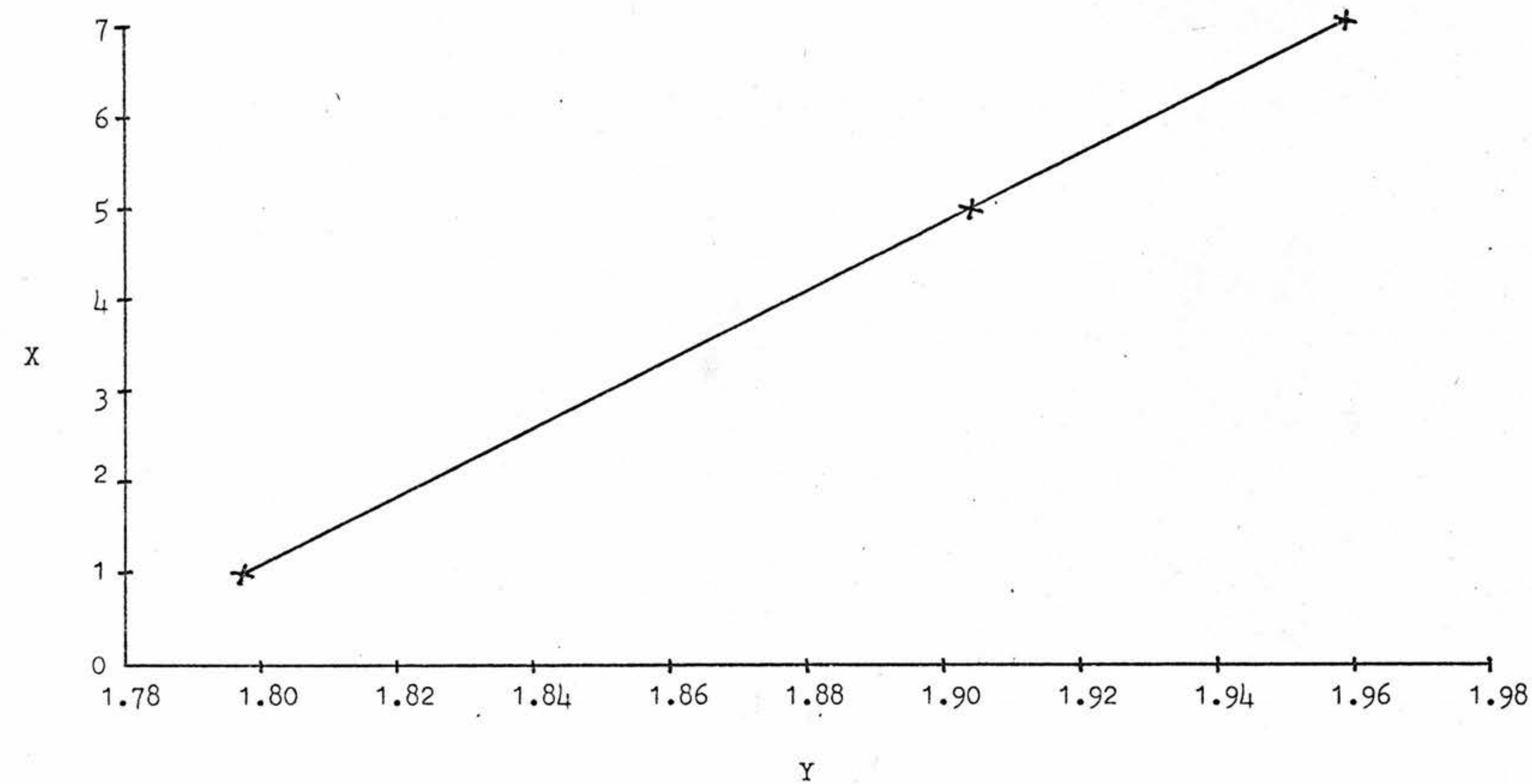
Fig 4.15

MODEL C



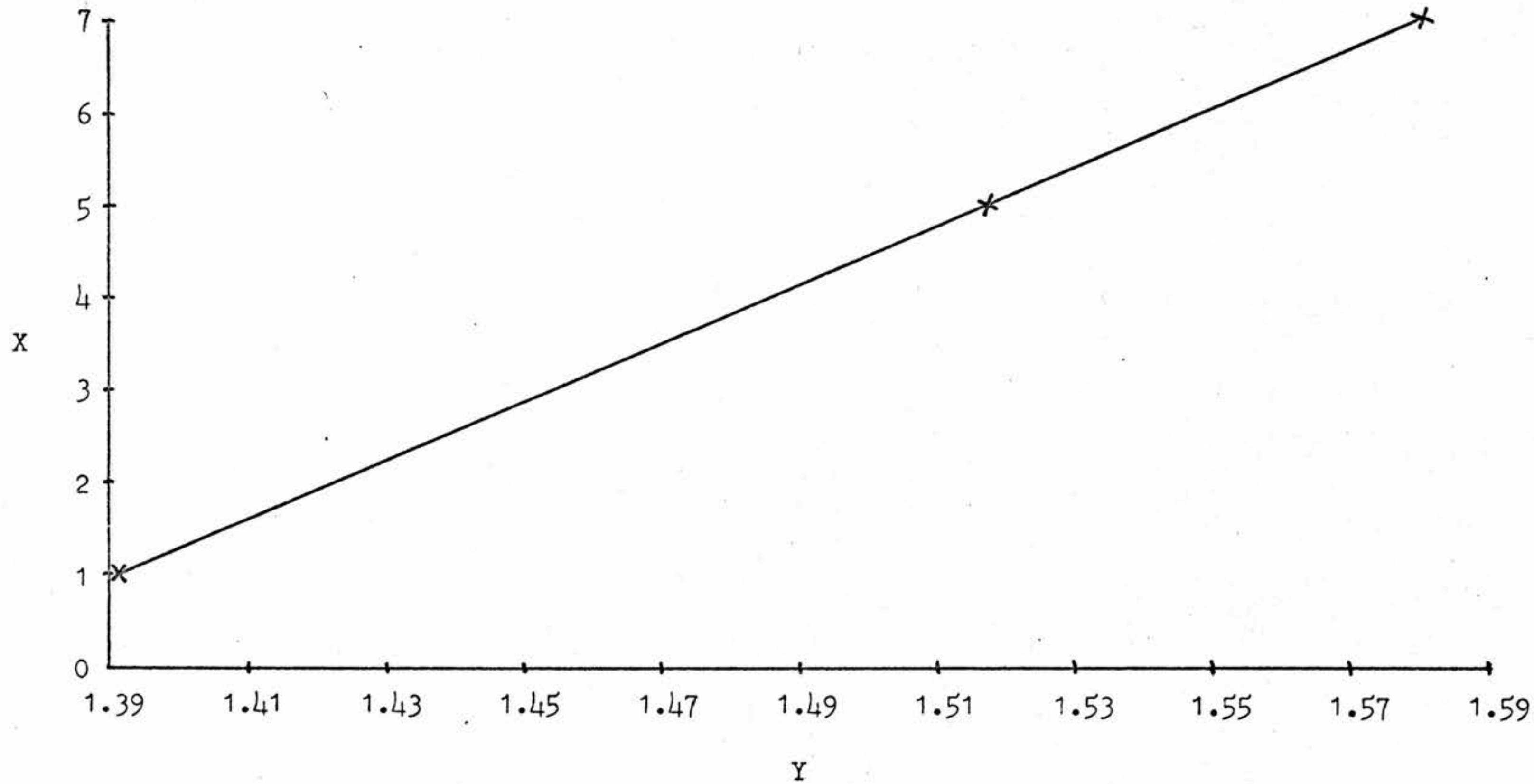
WEIGHT OF 7.16 KG ON NASAL BONES

Fig 4.16



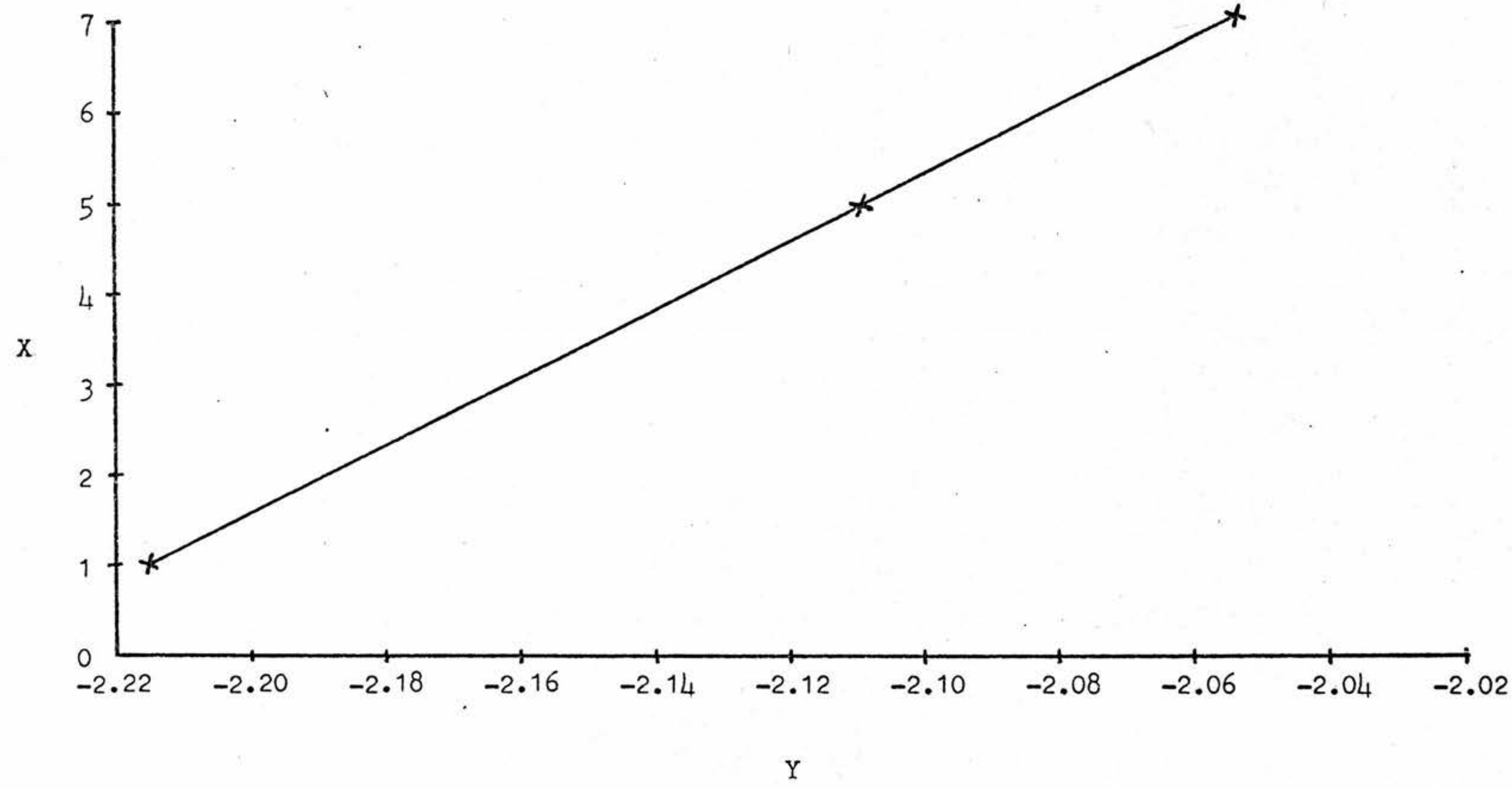
MODEL A - HIGH PRESSURE

Fig 4.17



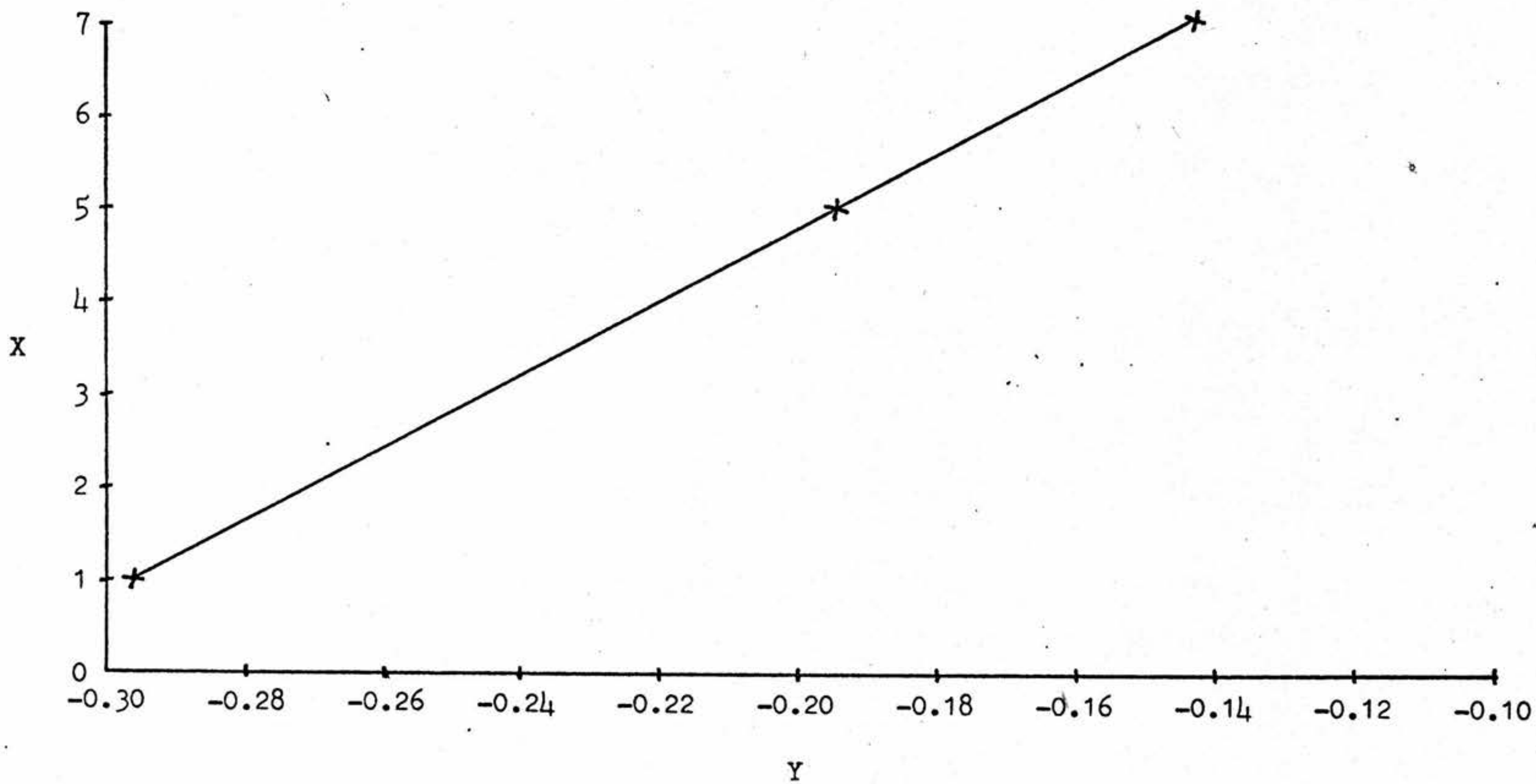
MODEL B - HIGH PRESSURE

Fig 4.18



MODEL B - LOW PRESSURE

Fig 4.19

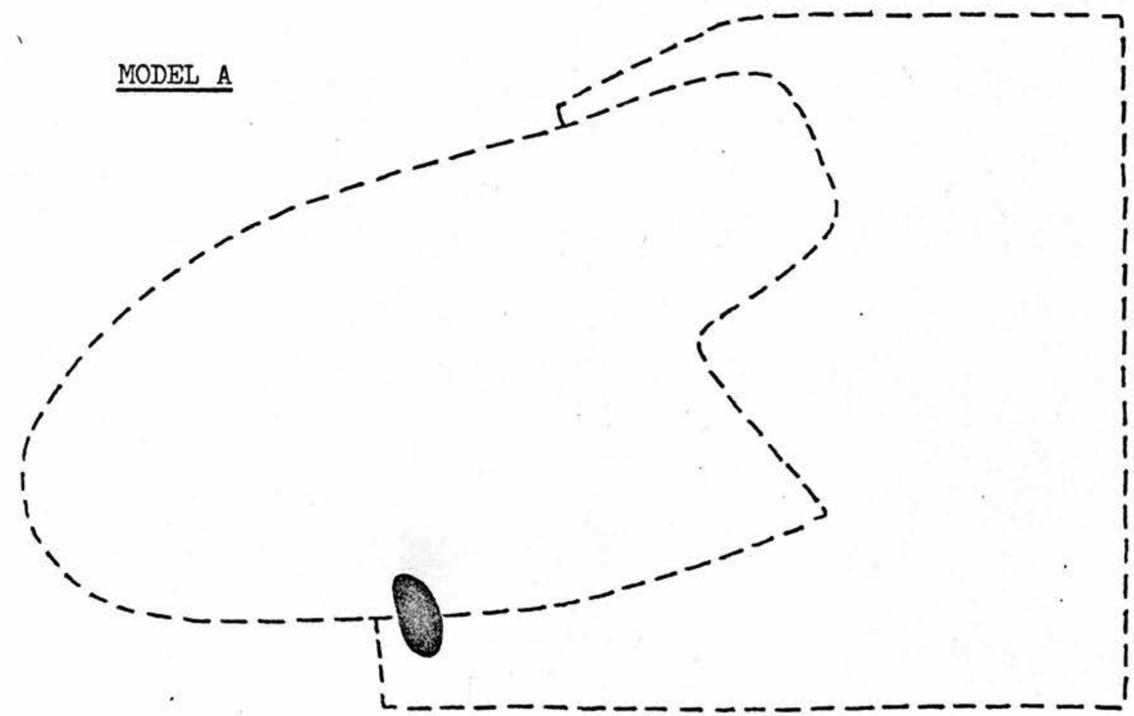


MODEL C - HIGH PRESSURE

Fig 4.20

MODEL A

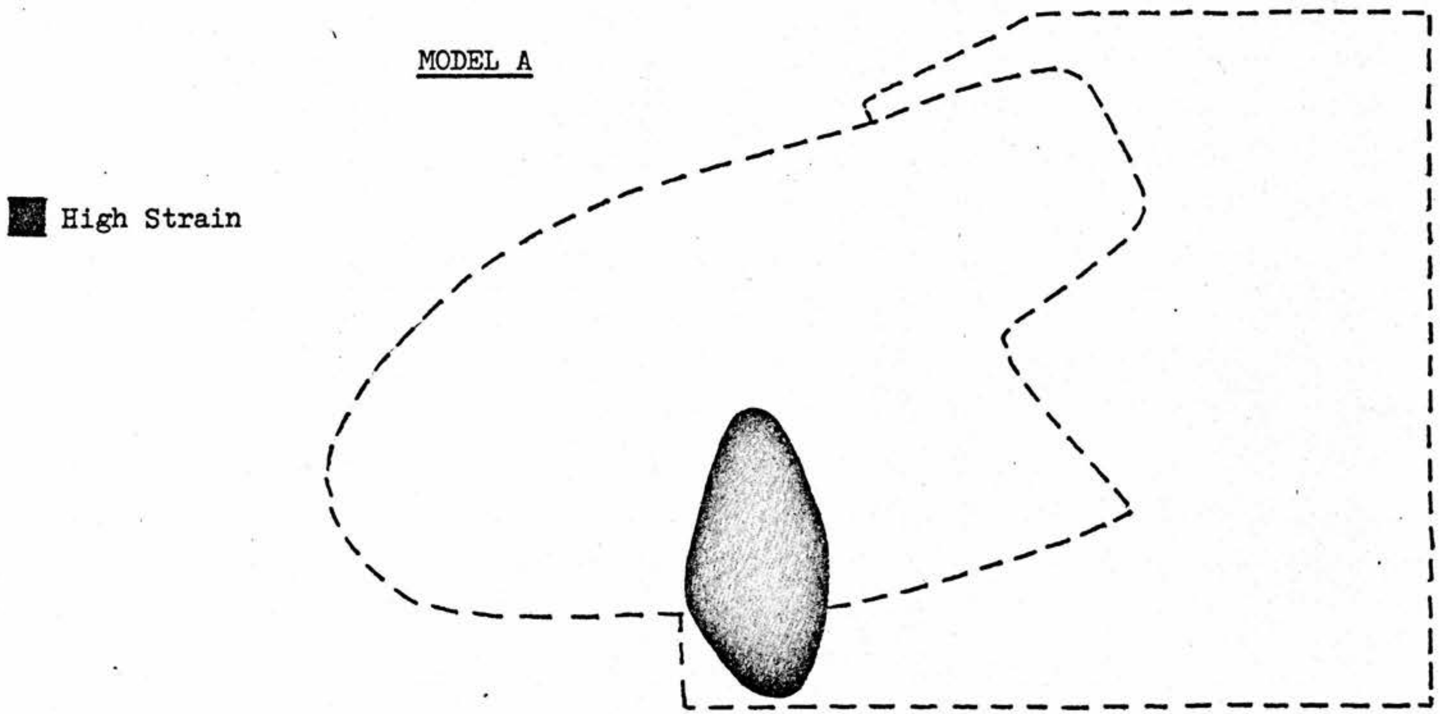
High Strain



WEIGHT OF 1.54 KG ON CARTILAGINOUS DORSUM

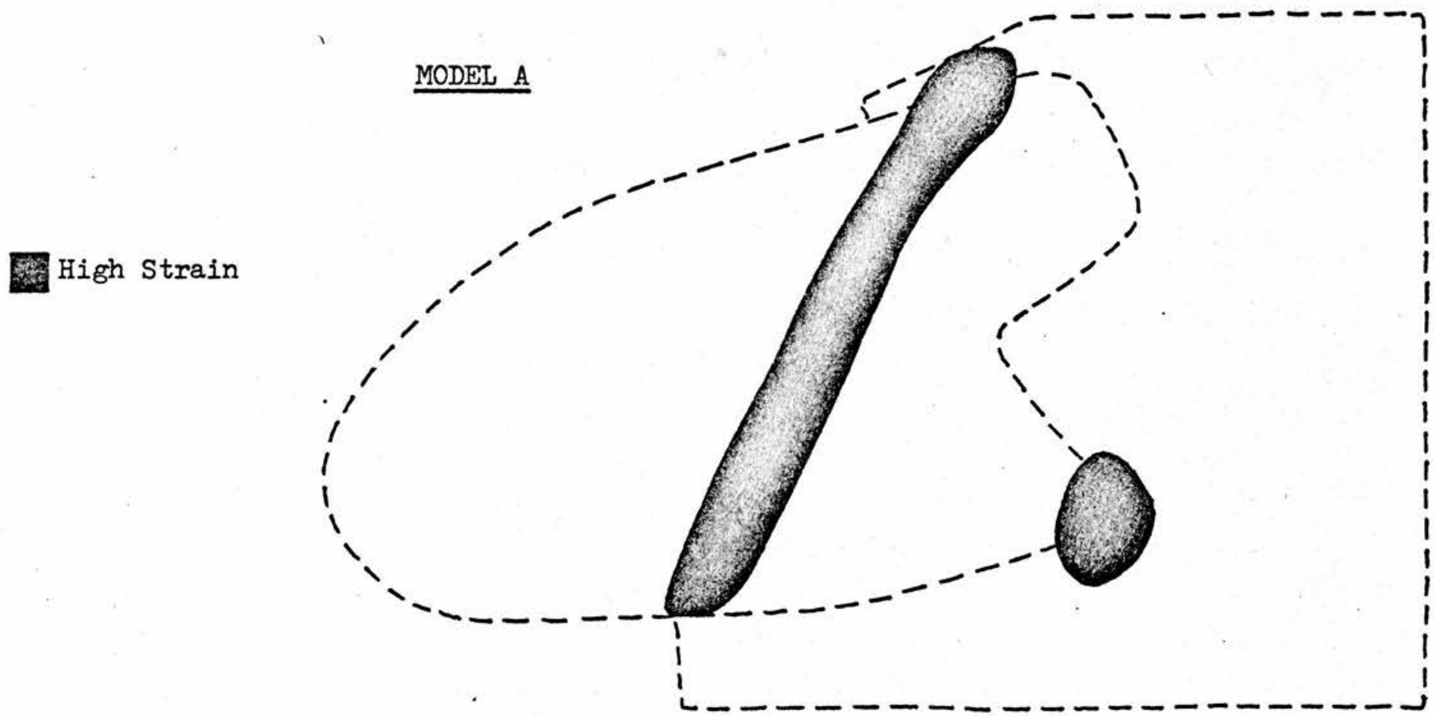
Fig 4.21

MODEL A



WEIGHT OF 4.5 KG ON CARTILAGINOUS DORSUM

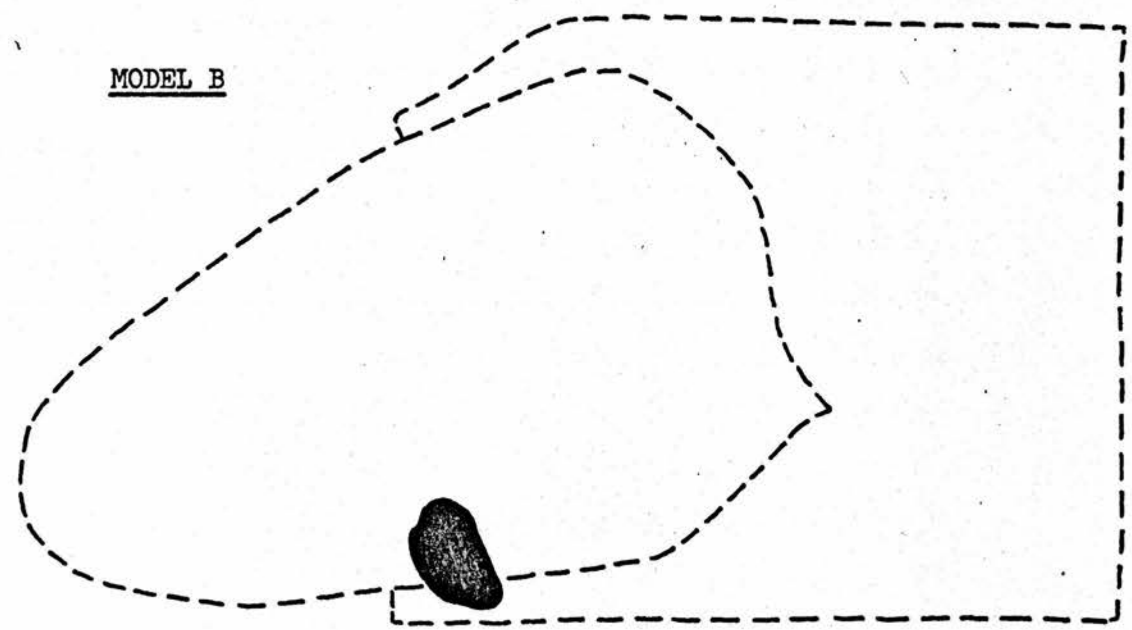
Fig 4.22



LATERAL WEIGHT OF 4.5 KG ON TIP OF SEPTUM

Fig 4.23

MODEL B

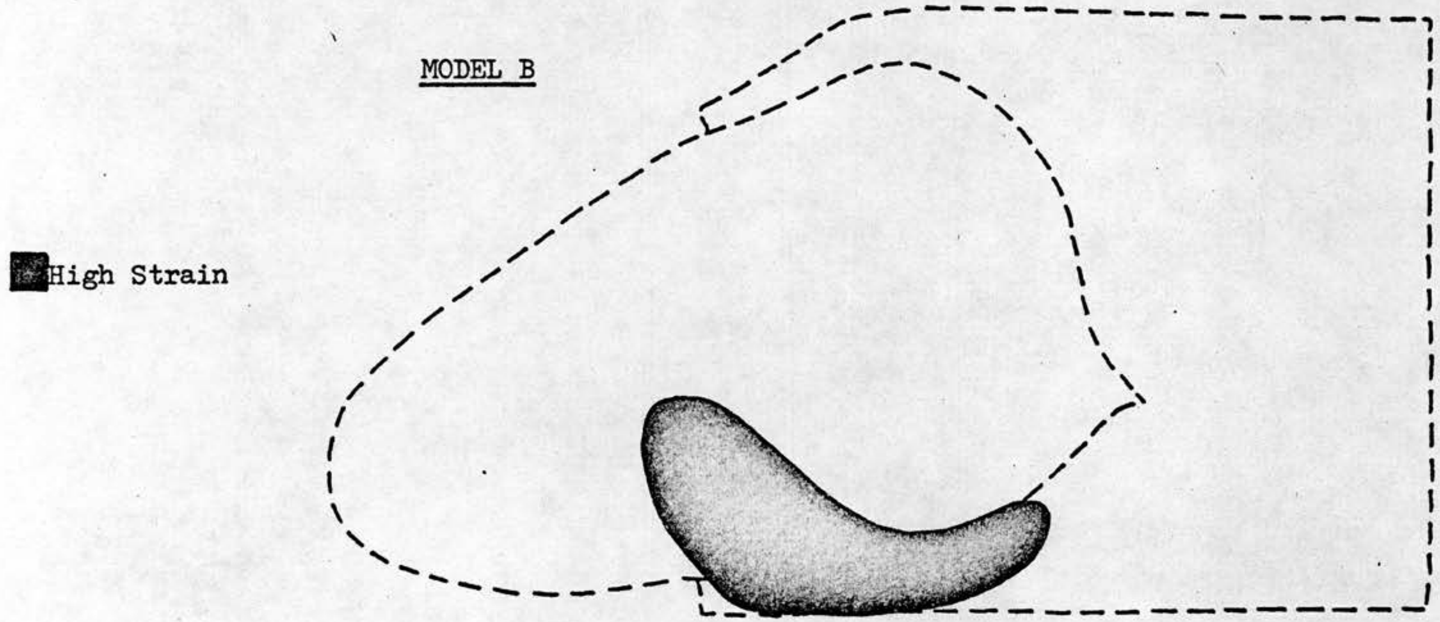


High Strain

WEIGHT OF 1.54 KG ON CARTILAGINOUS DORSUM

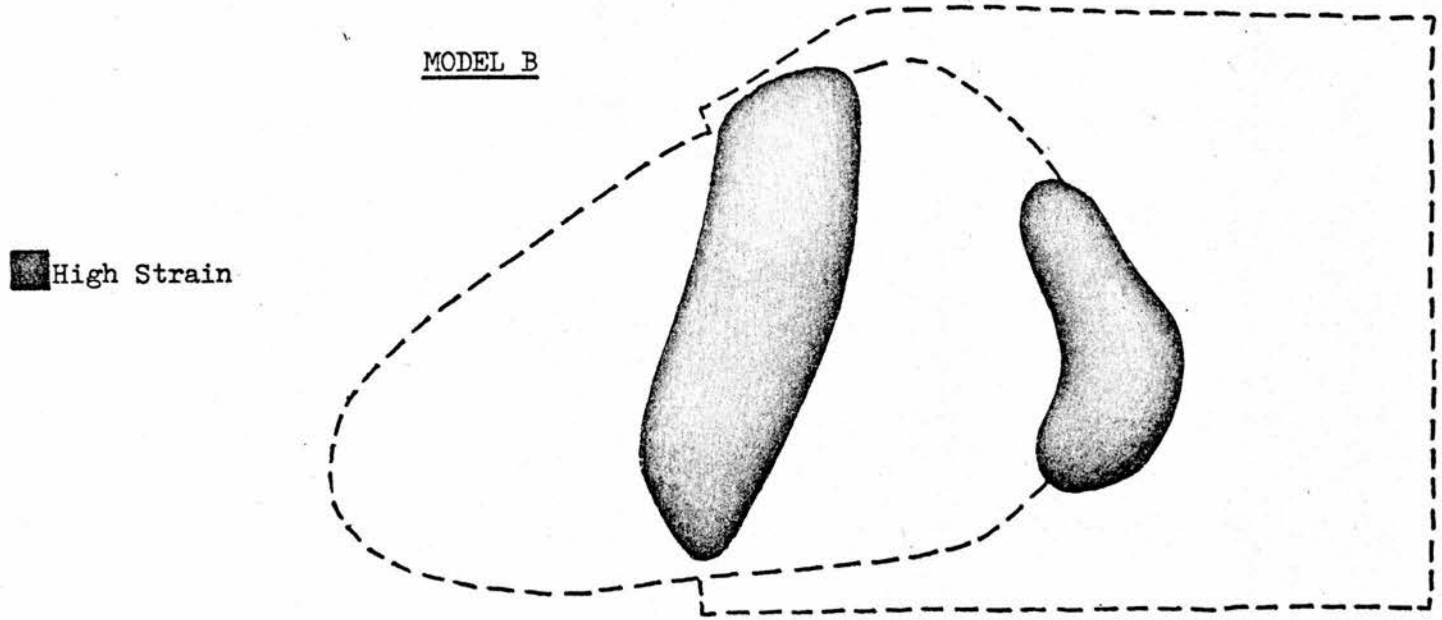
Fig 4.24

MODEL B



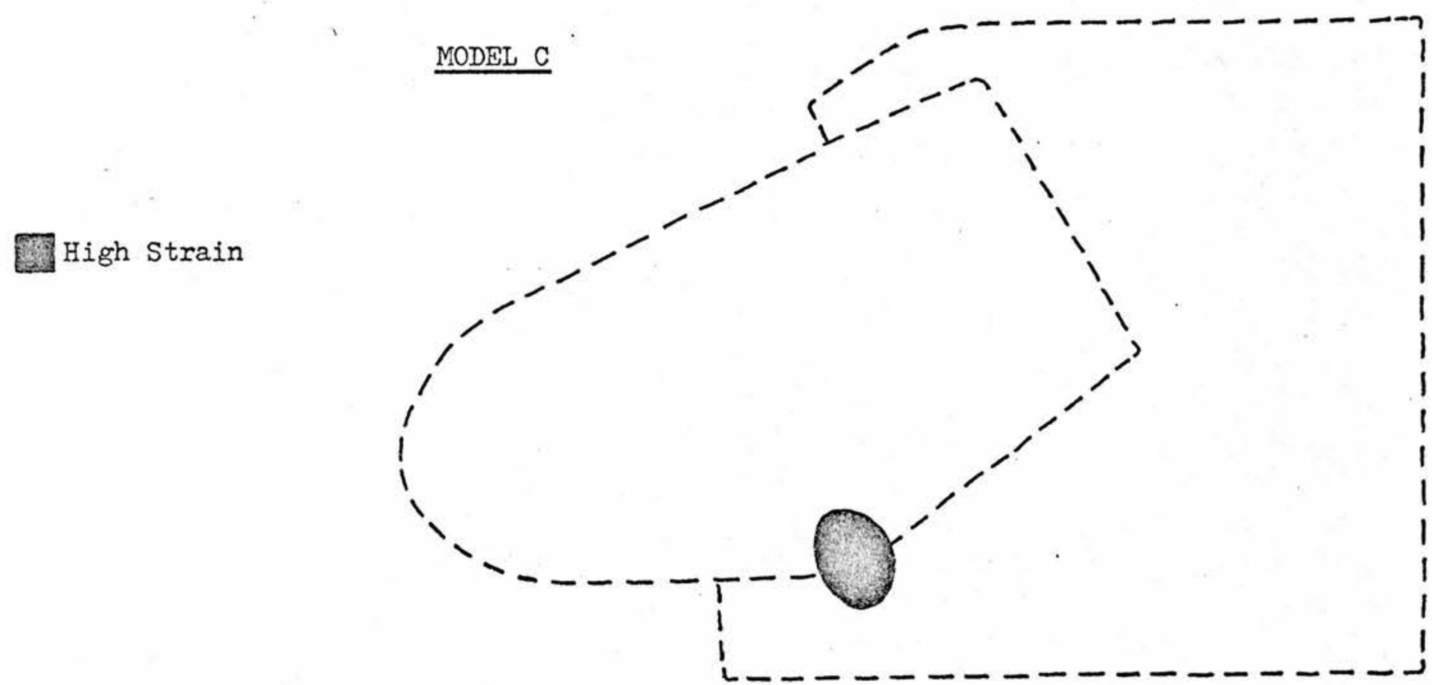
WEIGHT OF 4.83 KG ON CARTILAGINOUS DORSUM

Fig 4.25



LATERAL WEIGHT OF 4.5 KG ON TIP OF SEPTUM

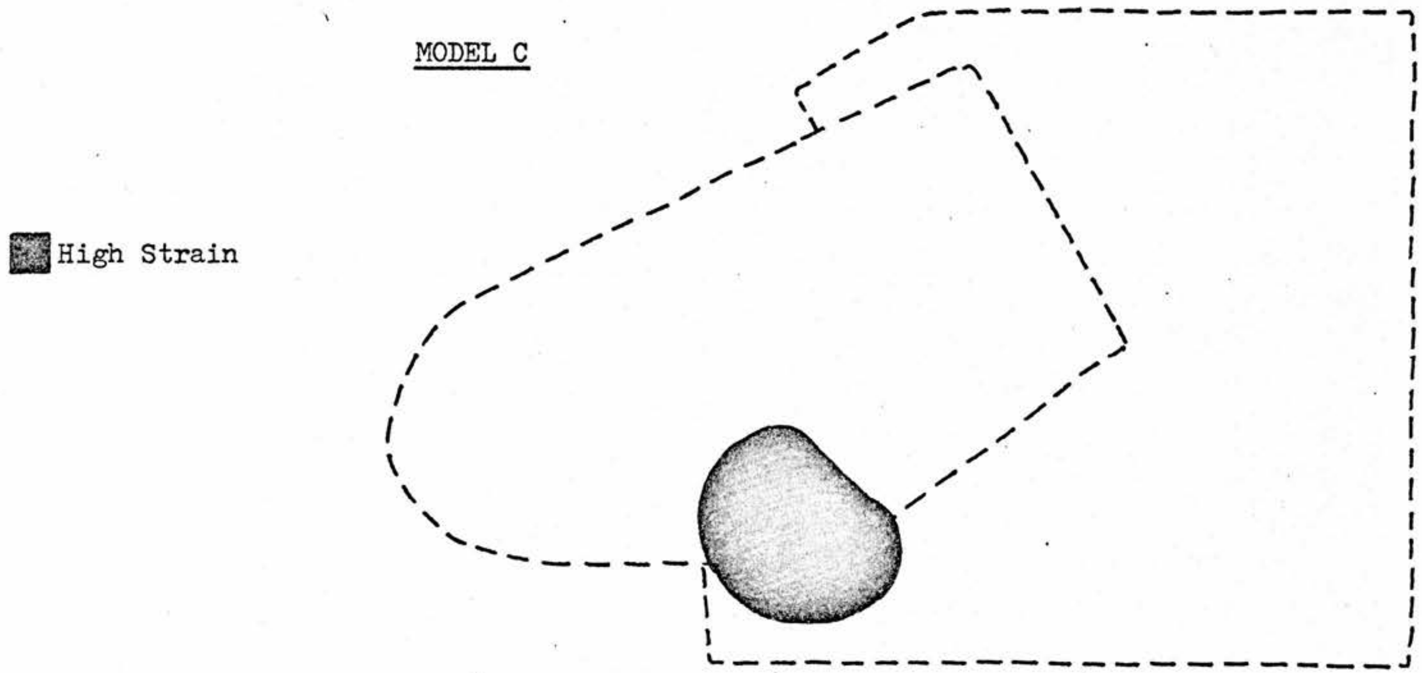
Fig 4.26



WEIGHT OF 1.54 KG ON CARTILAGINOUS DORSUM

Fig 4.27

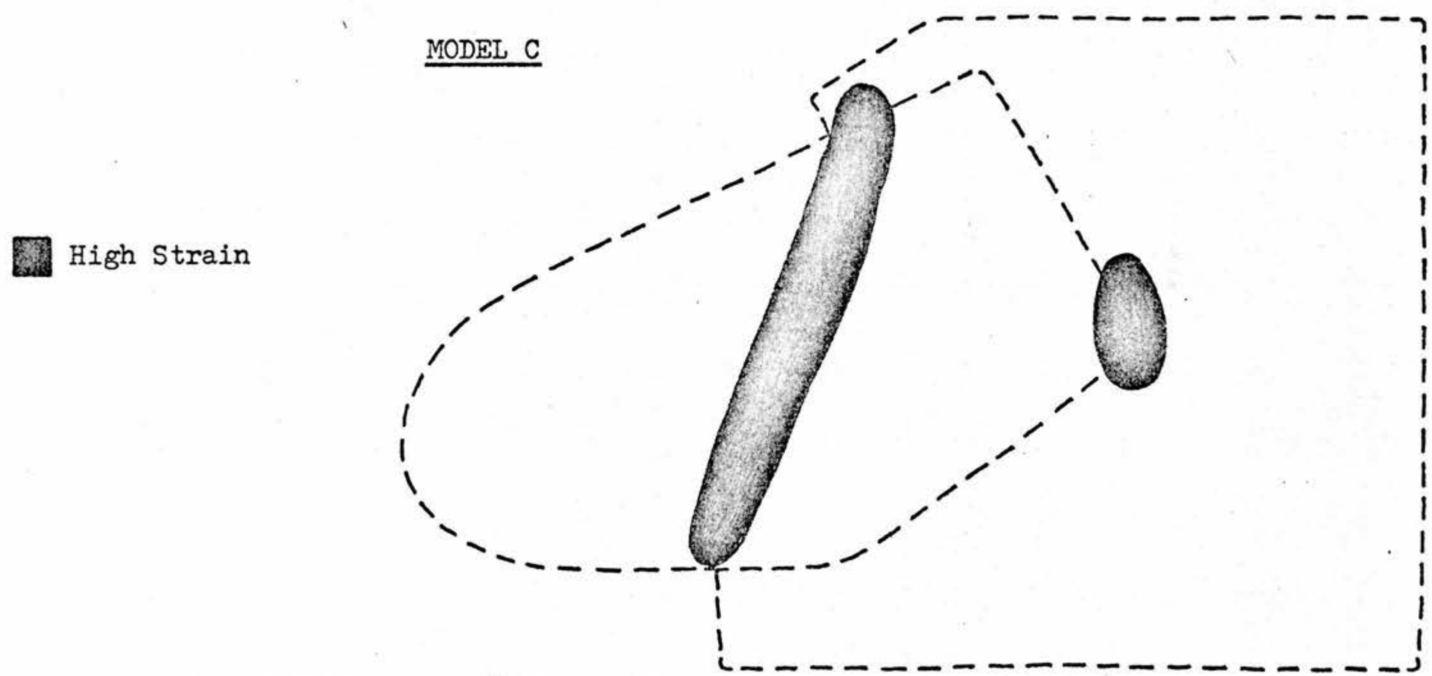
MODEL C



WEIGHT OF 4.5 KG ON CARTILAGINOUS DORSUM

Fig 4.28

MODEL C



LATERAL WEIGHT OF 4.5 KG ON TIP OF SEPTUM

TABLE 4.1

PERSPEX MODEL.

NASAL BONE STRESS.

Model	Weight (kg.)	Area (sq. cms)	High Pressure Squares	Low Pressure Squares
A	1.54	2.67 x 0.30	27	153
A	2.33	2.67 x 0.30	65	243
A	4.83	2.67 x 0.30	101	286
A	6.37	2.67 x 0.30	221	323
A	7.16	2.67 x 0.30	282	340
B	1.54	2.65 x 0.30	86	204
B	2.33	2.65 x 0.30	151	358
B	4.83	2.65 x 0.30	251	366
B	6.37	2.65 x 0.30	288	432
B	7.16	2.65 x 0.30	392	456
C	1.54	2.20 x 0.30	2	133
C	2.33	2.20 x 0.30	101	271
C	4.83	2.20 x 0.30	156	374
C	6.37	2.20 x 0.30	217	408
C	7.16	2.20 x 0.30	334	465

TABLE 4.2.

Weight (kg).	Area of Pressure	Force	Area of Low Pressure No. of squares	Area of High Pressure No. of squares
MODEL A.				
1.54	0.305 x 0.025	201.97	153	27
2.33	0.305 x 0.025	305.57	243	65
4.83	0.305 x 0.025	633.44	286	101
6.37	0.305 x 0.025	835.41	323	221
7.16	0.305 x 0.025	939.02	340	282
MODEL B.				
1.54	0.23 x 0.025	267.83	133	2
2.33	0.23 x 0.025	405.22	271	101
4.83	0.23 x 0.025	840.00	374	156
6.37	0.23 x 0.025	1107.83	408	217
7.16	0.23 x 0.025	1245.22	465	334
MODEL C.				
1.54	0.275 x 0.025	224.00	204	86
2.33	0.275 x 0.025	338.91	358	151
4.83	0.275 x 0.025	702.54	366	251
6.37	0.275 x 0.025	926.55	432	288
7.16	0.275 x 0.025	1041.45	456	392

TABLE 4.3.

PERSPEX MODEL.

NASAL SEPTAL STRESS.

Model	Weight(kg).	Direction	High Pressure Squares.
A	4.5	Lateral	284
A	1.54	Vertical	9
A	4.5	Vertical	108
B	4.5	Lateral	364
B	1.54	Vertical	17
B	4.5	Vertical	152
C	4.5	Lateral	232
C	1.54	Vertical	33
C	4.5	Vertical	121

DISCUSSION.

The importance of the septum in fractures of the nose has been emphasised many times in this thesis. The area of the septum most commonly involved in nasal trauma would appear to be the posterior two-thirds of the cartilaginous septum and the anterior one third of the bony septum. (Woodward 1935, White 1931, Moore & Harris 1940, Whitham 1939).

The pugilists' nose with a chronic hypertrophy of the perpendicular plate of the ethmoid and displacement of the vomer may reflect this. (Cohen 1949, Zorzoli 1950b). The combined bony cartilaginous septal deformity as described by Gray (1965a, b, 1969, 1974, 1978) which results from intrauterine and intrapartum pressure serves to confirm this clinical impression. By using this photo-elastic system to study the septum under stress, the area involved can be seen to have a high correlation co-efficient with the degree of stress. This area initially is at the bony cartilaginous junction near the vomer.

The build up of forces at this area may well explain the relation of spurs at the vomerine angle with trauma as suggested by Woakes (1890). The sudden appearance of spurs in this area following trauma in two of the cadaver experiments, gives further evidence to this theory. Further increase in the forces builds up pressure at the bony cartilaginous junction and the perpendicular plate of the ethmoid.

The similarity of distribution of forces in the septum, no matter the angle of delivery, is striking. This fact likewise may explain the translation of a direct frontal force to result in a laterally deviated fractured nose. As more forces are directed on the nasal bones, the anterior maxillary spine area is put under pressure. It is at this point that the well recognised clinical entity of a caudal dislocation of the nasal septum occurs. The fracture of Jarjavay and Chevallet may be recognised from the models which were stressed on the cartilaginous dorsum and laterally on the tip. A lateral deforming force on the tip yet again builds up pressure at the vomerine angle.

Hinderer (1972) suggested that the distance of the cartilage underneath the nasal bones could be critical to the mode of fracture of a nose and presumably, therefore, to the treatment. This distance he measured at 2-10mm in real life. No clear picture emerges from the results of this experiment on this point. Although for Models B and C, the correlation is good, for Model A, there is poor correlation. It would appear also that the shape of the bony cartilaginous junction has no effect whatsoever on the distribution of the lines of strain in the septum despite the assertion to the contrary by Takahashi (1977). (See Chapter 1).

The analysis of collagen lines in the human septum was attempted. It was not thought, however, to be particularly relevant as the articular cartilage of the knee is subject to different stresses from the nasal septal cartilage. The use of a circular awl as described by Hulkrantz (1898) and Ilberg (1939) to demonstrate the predominant alignment of collagen fibres was not useful because of the differing directions of the collagen fibres in differing layers of the cartilage.

Also the use of a scanning electron microscope and normal staining of sections of the cartilage to highlight collagen alignment were subject to the same criticisms. Neither of these latter two techniques were found to be beneficial.

CONCLUSIONS.

1. The use of a photoelastic material and bipolarized light is a valid method to demonstrate the distribution of forces in a stressed system.

2. The models used were a reasonable replica of the human septums.

3. The bony cartilaginous junction of the septum is the main area subject to high strains when the nasal bones are stressed from any angle.

4. Several different types of clinical abnormalities of the septum can be reproduced by a localised build up of forces in the models.

5. The shape of the bony cartilaginous junction of the septum and the area of cartilaginous septum under the nasal bones has no effect on the shape of fracture lines in the septum.

CHAPTER 5.

PHYSICAL BEHAVIOUR OF TRAUMATISED CARTILAGE.

INTRODUCTION.

Cartilage is composed of cells and an intercellular matrix containing fibres and ground substance. The structure and function of cartilage as in connective tissue are combined. The high water content within the viscous ground substance makes cartilage firm and turgid but also soft and flexible.

Differentiation from embryonal mesenchyme produces mature cartilage. Immature chondrocytes are initially formed which are closely packed. With maturation an intercellular matrix appears containing a fine dense network of collagen fibres. Simultaneously, chondrocytes produce and deposit ground substance which occupies interstices between the interlacing fibres. As the intercellular matrix accumulates between young chondrocytes, the cells are pushed progressively from each other.

The inner layer of perichondrium is chondrogenic producing immature chondrocytes (Seltzer 1956, Enlow 1968). Human nasal septal cartilage is known as hyaline cartilage because of its glassy appearance.

Costal cartilage has been used to replace the cartilaginous dorsum of the nose. This technique is not satisfactory as the graft subsequently was subject to warping and distorted the shape of the nose. This warping is particularly noted if the graft was taken from the outer layers of the cartilage. Methods of carving the graft to endure minimum distortion have been described by Gillies (1920) and Gibson & Davies (1958). Gillies thought that the distortion was due to contracture of the perichondrium but later Gibson & Davies (1958) disagreed with this conclusion. In principle, they agreed but found the main distorting forces were located in the perichondrium and that distortion occurred when the cortical and medullary portions of the graft were not balanced.

The rational explanation of the distortion in mechanical terms is that there exists in intact cartilage, a system of self-locked stresses and that partial release of these stresses or segmentation and trimming causes the observed distortion (Kennedi et al 1963, Abrahams and Duggan 1965).

Fry (1966a,b, 1967a,b,c,d,e, 1968a,b, 1969a,b, 1973, 1974, 1976), has published a considerable number of papers on the behaviour of cartilage when it has been damaged. He likens articular cartilage to a lateral half of septal cartilage. When articular cartilage is removed from underlying bone, it adopts a reversed saucer-like shape.

Fry proposes that within the nasal septal cartilage, there is an internal stress system whose outer layers derive their tensile strength from protein polysaccharides complexes parallel to the surface and anchored into the collagen fibrillar network. The septum remains stable because of internal expansile forces.

The collagen network is relatively inactive but provides support against which the protein polysaccharides can set up the tensile stresses.

The expansile forces depend on water retention. Incubation of the cartilage with cyanide to kill the chondrocytes had no effect on the physical properties of cartilage which suggests the stress system is a property on the components already laid down by cells. Chondrocytes have a slow metabolic activity. Chondrocyte viability should have been tested after this incubation to exclude their influence (Curran & Gibson 1956). This finding of Fry's may not, therefore, be valid.

Fry found that if the chondrocytes are arranged such that there appears to be well defined layers laterally, the behaviour of the septal cartilage differs from the type of septal cartilage with a uniform distribution of cells. He thinks the former type of cartilage bends more easily if one side is damaged. He also found that if the cartilage is thin, there is more chance of distortion with transgression of one side of the cartilage. Lateral alignment of chondrocytes and thinness of cartilage are characteristic of immature nasal septal cartilage. If the chondrocytes were randomly distributed throughout the ground substance of the cartilage, little distortion occurs if one side of the septum is damaged. He found this by scoring strips of post mortem human cartilage on one side which produced a deviation to the opposite side. All Fry's work mentioned overleaf has been in vitro. He used the rabbit as a model for the human nasal septum.

The rabbit septum is naturally straight being surrounded in 90% of its periphery by bone. After one side of the growing rabbit's cartilaginous septum was scored, the septum subsequently grew in a deviated manner away from the scored side. Despite all these impressive experimental findings, the behaviour of the human nasal septum in vivo appears to be quite different. It would appear to be possible to straighten a deviated septum by scoring the concave side during a septoplasty operation, but the initial pleasing result is all too often found to have failed at the three-monthly follow-up check. The incidence of recurrent deviations of the nasal septum after a septoplasty operation is depressingly high. An attempt to circumvent this problem is suggested by Rubin (1969). He designed a morselizer which destroys the "spring" on both sides of the septal cartilage. This allows the septum to remain straight and the long term results from this procedure are said to be good.

As previously stated, the expansile forces present in the interlocked stress system are maintained by water retention. The deformation which occurs with normal walking movements in the articular cartilage of the femur is associated with a flow of fluid from one area of the cartilage to another. Permanent deformation has not been demonstrably linked with a change in the fibrillar network. (Benninghoff 1924, 1925a, b, 1939, Elmore et al 1963, Linn & Sokoloff 1965).

Fry believes the origin of the deformation of nasal septal cartilage after injury is a re-distribution of fluid in association with alteration in the fibrillar network. His evidence for this assertion comes from his incubation experiment. Septal cartilage was incubated with papain and hyaluronidase to remove the protein polysaccharide complexes. Although the internal interlocked stress system was removed, the shape of the nasal septum remained constant.

Subsequent incubation of the same pieces of cartilage with collagenase destroyed all the cartilage's elastic properties. His conclusion was, therefore, that the collagen maintains the shape of the septum and the protein polysaccharide complexes are responsible for internal interlocked stresses.

Little other work on the human nasal septum in this field has been published. Articular cartilage on the other hand has been extensively investigated because of its relevance to rheumatoid arthritis. Structurally, articular cartilage consists of a relatively coarse collagen fibre network and a much finer molecular network or proteoglycans fibres and water. Proteoglycans are hydrophilic molecules which swell in the presence of water to form gels. Gels possess an elastic resistance to expansion so that a particle of gel in water will swell until the swelling tendency is balanced by elastic forces in the molecular chains. Cartilage consists of a large number of gel particles emeshed in collagen fibres which check the swelling pressure. In unloaded cartilage, tensile forces in the collagen fibres produce an internal hydrostatic pressure equal to the osmotic pressure of the proteoglycan gel (Kempson 1980).

In experiments on articular cartilage, Kempson found that when a force is applied to the cartilage, the equilibrium between the forces generated by the swelling pressure and the tensile forces in the collagen fibres is disturbed. The tissue deforms instantaneously and if the force is maintained beyond the instantaneous deformation phase, the cartilage continues to deform with time until it reaches a final deformation equilibrium. During this deformation, the water is expressed from the tissue and as a consequence of the increased concentration of the proteoglycans, the swelling pressure of the matrix rises.

The equilibrium deformation is the point at which the applied force is balanced by the forces due to the increased swelling pressure with perhaps some contribution from the collagen mesh. The collagen fibres do not resist initial compression but do counteract expansion.

It is the osmotic pressure of the fluid within the cartilage which is responsible for the resistance to compression and not to any forces within the solid components of the matrix. Thus swelling pressure in the cartilage is due primarily to the proteoglycans elastic stresses due to the collagen network. (Madouradas 1979).

Structural failure of cartilage may occur if the tensile stresses become such that the swelling pressure in the aqueous proteoglycans gel increases to burst a tissue. This mechanism is known to produce splits in cartilage of human joints and compression injuries. Permanent deformation of the cartilage may result if cyclically applied load of great magnitude over long periods managed to express enough water from the cartilage (Weightman and Kempson 1979).

This then is the premise of Fry. He believes that nasal trauma in some way instantaneously deforms the nasal septum and the fluid is re-distributed according to the re-arranged pressure. He believes the increased swelling pressure of the aqueous proteoglycans gel produces minute cracks which appear throughout the outer layers of the stressed septum. The collagen fibres and the proteoglycans of the cartilage re-arrange themselves accordingly if the initial deformation remains after the instantaneous phase and a septal deviation will occur.

If this deviation is not resolved soon after it occurs then surgical straightening of the nose will be doomed to failure unless the collagen network is completely disrupted as with a morselizer. Fry believes that minute cracks appear in the convex surface of the deviated septal cartilage i.e. the cartilage bursts because of a localised increase in the concentration of aqueous proteoglycans. This subsequently leads to increased deformation of the cartilaginous septum which increases with time. Although Fry believes nasal manipulation is a good operation with acceptable results, he believes this fluid movement with the re-arrangement of collagen fibres denies the perfect results which should be obtained in straightening a septum.

The premise that nasal trauma does indeed deform the cartilaginous septum to produce a build-up of forces and hence produce minute cracks along the side of the septum and thereafter produce a septal deviation, requires to be tested. This experiment makes use of nasal septal cartilage which has been traumatized in a controlled fashion. Any deviation of the cartilage is closely scrutinized following a period of incubation in a physiological solution. If Fry's premise is correct, one would expect movement of water through cartilage and the formation of minute cracks in one side of the septum which in turn would lead to a deviation of the cartilage.

METHODS AND MATERIALS.

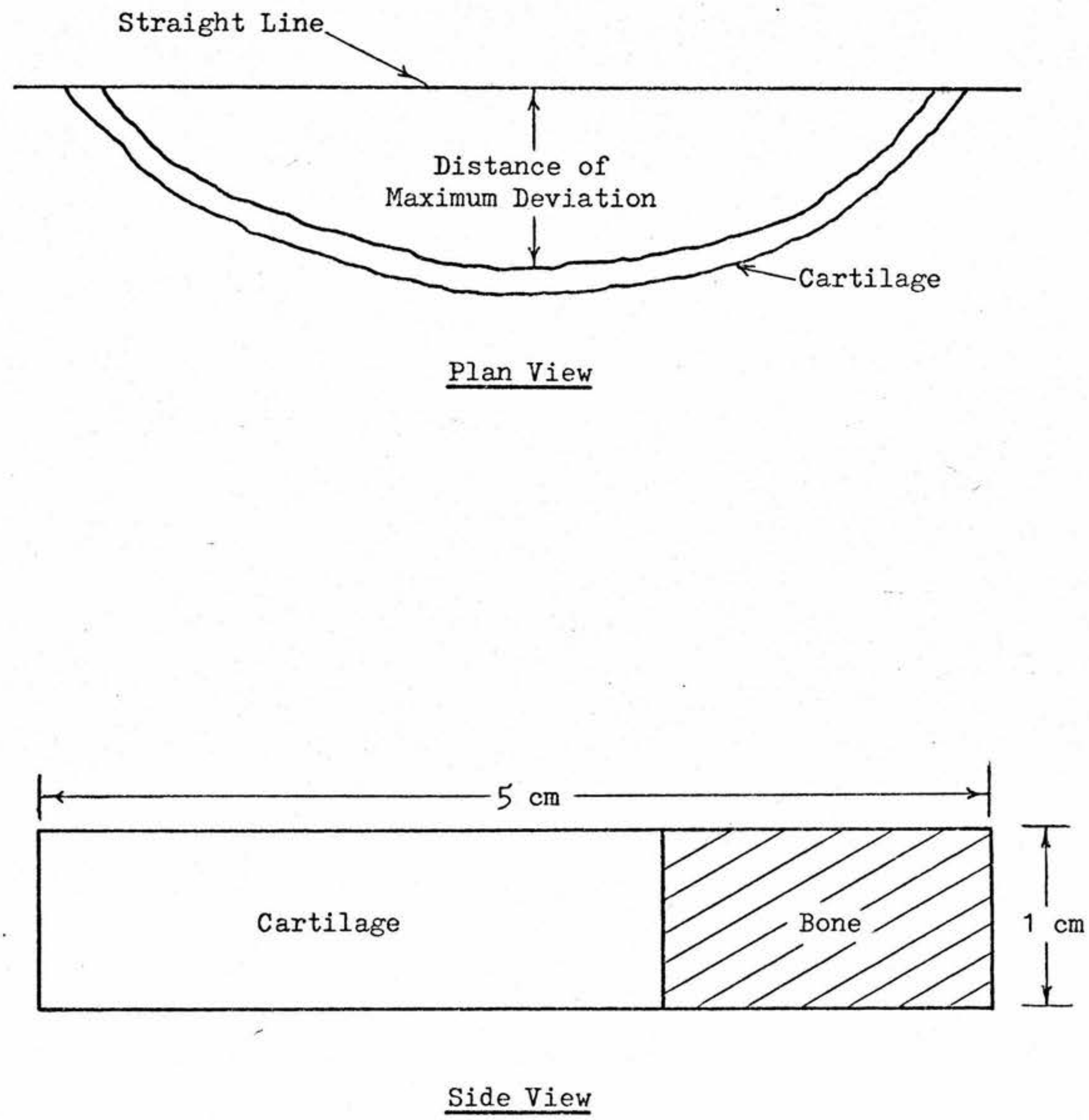
Ten septums were taken from those cadaver bodies used previously (Chapter 3). Each of these bodies had been hit with a force to create a fracture of the nasal bones such that both nasal bones were fractured. Gross septal damage was restricted to the upper most part of the septum. No obvious fracture was incurred in the areas of septum tested. Five septums were also taken from the control bodies which were not traumatised. Great care was taken to remove the septums as atraumatically as possible. This included mobilisation of the posterior end of the septum following the removal of part of the sphenoid. Each septum was then measured length-wise from the bony end. Any excess over 5cm was trimmed off. The first two preliminary specimens which were discarded did not have the mucoperichondrium removed. With subsequent incubation, they became quickly rotten and unuseable. All the septums under consideration therefore, had the mucoperichondrium removed prior to incubation.

The septum was then divided into four horizontal strips of 1cm height, nominated A, B, C and D. These strips included the cartilaginous septum and the bony septum to a variable extent. Those strips higher up the septum contained relatively less bone compared with the lower strips which comprised almost 50% bone. This distribution resulted from the varying amount of bony cartilaginous relationships in the septums. The area of septum was closely studied therefore, was the bony/cartilaginous interface i.e. the area highlighted in Chapters 3 and 4.

Each strip was then placed vertically on end on a perfectly straight line and allowed to adopt its natural position in the same plane as the septum in the human. The ends of the strip were aligned with this line. The point of maximum deflection was noted using a pin to record accurately on the paper. The distance of these pin-points from the straight line were subsequently measured using inside measuring Vernier calipers accurate to 0.1mm. (Fig 5.1). Each strip was then placed in a bath of oxygenated ringer-lactate solution and incubated at $37^{o}C$ for 72 hours. The temperature of the bath was constant as measured with a mercury thermometer. No preservative was placed in the solution to avoid any undue influence in the behaviour of cartilage following trauma. After 80 hours of incubation, the cartilage became foul thereby invalidating the results. It is also appreciated that by this time, the chondrocytes will have died.

Following 72 hours of incubation, the strips of cartilage were removed from the bath. Excess water was removed and the cartilage strip was re-measured as previously described. The results were tabulated and compared with the pre-incubation results.

Fig 5.1



VIEW OF SEPTUM LYING ON STRAIGHT LINE

RESULTS.

The results are shown in (Table 5.1). From raw data, it is apparent there has been little, if any, movement or further deviation of the cartilage following trauma. Likewise, the control septums have shown little change in the amount of deviation. For each septum, the measurements of deflection from the straight line were summed as in (Table 5.2).

A Wilcoxon Rank Sum Test was used to determine the significance of difference of the results of before and after incubation (Table 5.3). Using Tables D and E in Statistics At Square One 1979 published by The British Medical Journal, the difference in the deviations between the experimental septums before and after incubation are not significant. Likewise, the difference between the experimental and control septums are not significant.

TABLE 5.1

MAXIMUM POINT OF DEVIATION. (in centimetres).

Before Incubation.

Septum	A	B	C	D
1.	0.39	0.08	0.37	0.49
2.	0.23	0.38	0.48	0.37
3.	0.40	0.41	0.64	0.82
4.	0.32	0.27	0.37	0.69
5.	0.35	0.50	0.37	0.31
6.	0.10	0.75	0.61	0.47
7.	0.35	0.51	0.82	0.51
8.	0.10	0.21	0.43	0.71
9.	0.61	0.85	0.62	0.49
10.	0.32	0.81	0.56	0.81
Controls				
11.	0.15	0.21	0.40	0.62
12.	0.43	0.41	0.72	0.79
13.	0.14	0.92	0.66	0.20
14.	0.27	0.18	0.45	0.35
15.	0.75	0.21	0.17	0.55

TABLE 5.1.

MAXIMUM POINT OF DEVIATION. (in centimetres).

After Incubation.

Septum	A	B	C	D
1.	0.33	0.12	0.36	0.41
2.	0.24	0.39	0.54	0.40
3.	0.36	0.45	0.63	0.76
4.	0.30	0.30	0.50	0.63
5.	0.31	0.52	0.39	0.30
6.	0.19	0.69	0.58	0.42
7.	0.33	0.47	0.80	0.58
8.	0.15	0.25	0.38	0.69
9.	0.63	0.84	0.60	0.52
10.	0.35	0.85	0.49	0.85
Controls				
11.	0.18	0.23	0.39	0.65
12.	0.47	0.47	0.75	0.76
13.	0.18	0.79	0.59	0.26
14.	0.31	0.21	0.39	0.32
15.	0.69	0.24	0.20	0.49

TABLE 5.2.

SUM OF MEASUREMENTS. (centimetres)

MAXIMUM DEVIATION FOR A+B+C+D.

	Before Incubation	After Incubation	Difference
Septum			
1.	1.33	1.22	0.11
2.	1.46	1.57	-0.11
3.	2.27	2.20	0.07
4.	1.65	1.73	-0.08
5.	1.53	1.52	0.01
6.	1.93	1.88	0.05
7.	2.19	2.18	0.01
8.	1.45	1.47	-0.02
9.	2.57	2.59	-0.02
10.	2.50	2.54	-0.04
Controls.			
11.	1.38	1.45	-0.07
12.	2.35	2.45	-0.10
13.	1.92	1.82	-0.10
14.	1.25	1.23	0.02
15.	1.68	1.62	0.06

TABLE 5.3.

WILCOXON RANK SUM TEST.

Septums	Signed Rank (without controls).	Signed Rank (with controls)
1.	$9\frac{1}{2}$	$14\frac{1}{2}$
2.	$-9\frac{1}{2}$	$-14\frac{1}{2}$
3.	7	$9\frac{1}{2}$
4.	-8	-11
5.	$1\frac{1}{2}$	$1\frac{1}{2}$
6.	6	7
7.	$1\frac{1}{2}$	$1\frac{1}{2}$
8.	$-3\frac{1}{2}$	-4
9.	$-3\frac{1}{2}$	-4
10.	5	6
11.	–	$-9\frac{1}{2}$
12.	–	$-12\frac{1}{2}$
13.	–	$12\frac{1}{2}$
14.	–	4
15.	–	8

INACCURACIES.

1. The average age of the bodies from which the specimens were taken was 68 years of age. This is older than those patients who are included in the clinical trials i.e. those on whom one would ordinarily consider surgery. The water content of cartilage has been found to decrease with age (Madouradas 1979). As previously stated, the water content of cartilage is probably important in the production of a deviation.

The use of younger bodies for this experiment was not possible as all those available during the time of experiment had either died from a wasting or a metabolic disease e.g. leukemia, renal failure or had been involved in violence and were under the jurisdiction of the Forensic Pathologist. The use of cartilage from submucous resection specimens was also considered but an adequate standardisation of application of violence was not possible hence invalidating this possibility.

2. The experiment was not in vivo. This latter again was not possible for obvious reasons. As a compromise, the cartilage was incubated in a physiological solution at a physiological temperature and was oxygenated for the time while the chondrocytes were viable.

During the same period, pieces of septal cartilage scored on one side left at $20^{o}C$ in the air did produce marked bending to the opposite side as was found by Fry.

3. The above experiment does not allow for bleeding under the mucoperichondrium. Occasionally, young children develop a post traumatic septal haematoma which may result in the re-absorption of part of the cartilaginous septum (Fry 1969a). If this occurred on one side of the septum only, the interlocked stress system on this side would be abolished and a septal deviation is the result.

This hypothesis agrees with the world knowledge of nasal septum behaviour and also with the findings of this experiment.

DISCUSSION.

The cartilaginous septum may deviate in many different ways. The descriptions on names attached to the different types of deviation vary from author to author. The following are a consensus of names and descriptions.

1. A fracture of the septal cartilage. This need not be a total fracture; in children in particular, the fracture may be a greenstick.

2. The lower end of the septum may fracture off the maxillary crest. This results in a so-called dislocation although cartilage is still present in the maxillary groove.

3. The formation of the maxillary crest may be deficient and hence the groove to hold the septum is inadequate. This results in a true dislocation of the septum.

4. A spur may appear at the vomerine angle or nearby. Gray (1978) suggests that these may result from trauma.

5. Fry (1968) believes that those septal deviations which do not fit into the above categories result from the unilateral release of the interlocked internal stress system of the cartilage by trauma. This experiment does not appear to support this view. Fry extrapolates the behaviour of human septal cartilage in vitro and the rabbit septal cartilage in vivo to the human septal cartilage in vivo.

Harrison (1979) performed a similar experiment to that reported in this thesis. He stored the bony cartilaginous sections taken from traumatised cadavers in normal saline at room temperature for three months. A comparison of photographs at the begining and at the end of the experiment was made. He found no change in the 3 months. A number of criticisms of this work can be made. The bony cartilaginous specimens were not standardised in size. No controls were used. His temperature of storage was 20°C and his solution was saline both of which are not physiological.

After 72 hours, chondrocytes die, a fact which could change the behaviour of the cartilage. A similar pilot experiment was carried out by the author which resulted in foul smelling decaying cartilage. Either some preservative must have been used in Harrison's incubation solution which could upset the results or the temperature may have been even lower than 20°C to delay putrefaction. The use of photographs to assess change over this time is not adequate as there is no standardisation of views or focal length of the pictures.

These faults were rectified in the author's experiment but needless to say other faults were substituted as have been detailed.

Fry (1969a) has shown that the presence of a septal haematoma leads to cartilage necrosis and resorption. The only theory that would suit all the known facts is to suggest that the formation of a thin layer of subperichondrial haematoma on one side of the septum may be the result of trauma.

This could lead to resorption of the outer layer of cartilage on this side which in turn allows the internal interlocked stresses to be released to form a deviated septum.

CONCLUSIONS.

1. The septum in a damaged nose probably behaves in a regular fashion and does not apparently exhibit evidence of an internal interlocked system of stresses.

2. The term deviated septum covers many different anatomico-pathological entities. The principle of Fry as a cause has not been substantiated in the human in this experiment.

CHAPTER 6.

A NEW APPROACH TO THE PROBLEM OF A NASAL FRACTURE.

INTRODUCTION.

Interest has been shown in the treatment of a fractured nose throughout medical history. A critical evaluation of the modern day approach has, until relatively recently, been lacking. The principles used today are much the same as those described 5,000 years ago. The evidence presented in Chapter 2 of this thesis indicates that the accepted method of treatment of nasal fractures is inadequate. Chapter 3 demonstrates that if the nasal bones are deviated from the midline by more than one half breadth of the nose, the perpendicular plate of the ethmoid is inevitably involved. Greater deviation of the bones involves a larger fracture of the septum. The reason for this involvement would appear to be the architectural structure of the nose rather than inherent behaviour of the materials of the nose. This chapter is devoted to a comparison of the accepted treatment and a different type of treatment of a nasal fracture. This treatment has been devised and amended consequent on the knowledge gained in the preceding chapters.

PATIENTS AND METHODS.

Provision was made by the author for an out-patient clinic specifically to diagnose and treat nasal fractures. Only the fractures restricted to the nasal complex were seen at this clinic, the more complicated fractures involving the other facial bones or orbit were treated in other departments. Patients were referred to this nasal trauma clinic from Local General Practitioners and the Casualty Department of the Royal Infirmary of Edinburgh. Referrals did come from elsewhere but no definite arrangement was organised. The majority of patients with recent nasal trauma in Edinburgh were seen by the author.

Those patients who required no further treatment were discharged. Some patients were asked to re-attend the clinic at a later date as gross soft tissue prevented a good assessment of the shape of the nose on the first visit. A large number of patients were assessed at this clinic but only a few were admitted to the trial as the acceptance criteria were strict. No person of less than fifteen years of age was included.

This precaution was adopted because of the controversy surrounding the growth of the nose and middle third of the face following septal surgery. No one who had had a previous nasal injury was included. Only those people who were willing to co-operate in the trial were included. No upper age limit was imposed but the majority of the people over the age of sixty years were unwilling to be included in the trial.

Deformity of the nasal bones was graded in the following manner:-

Grade 0	Perfectly straight.
Grade 1	0-$\frac{1}{2}$ nose width deviation from the midline or the previous shape.
Grade 2	$\frac{1}{2}$-1 nose width deviation.
Grade 3	Greater than one nose width deviation.
Grade 4	The deviation was so great that the bones almost touched the nose.

The reason for this grading as opposed to measuring the distance from the inner canthi is that one instinctively assesses the nose shape compared with the rest of the face. A short, fat nose on a short, fat face may not appear greatly deviated compared with a long, thin nose on a long thin face even if the distances of deviation are identical.

This grading method in the author's opinion, appears to be accurate and reflects the apparent asymmetry of the nose better than a measurement. It is also easy to grade this in the clinical context and it proved a useful adjunct in the management of a fractured nose. Only those patients with a Grade 2 deviation or more were initially included in the trial. Unfortunately, this meant the numbers in the trial were very restricted and subsequently, this criterion was relaxed. In fact, only two patients with a Grade 1 deviation were included in the trial.

The details noted at this clinic were the patient's name, age, sex and hospital number. Five basic aetiological groups were identified, road traffic accidents, sport, assault and other causes. All the assessments were carried out by the author. The side of the deviation of the nasal bones was noted as was the grading of the deviation of the nasal bones. Depression of the nasal bones was also noted. Deviation from the midline of the external cartilaginous dorsum was assessed and a similar grading to that of the nasal bones was made.

The presence of a dorsal depression of the cartilaginous septum was noted. Internal deviation of the nasal septum were divided into bony or cartilaginous. The cartilaginous deformities were either a fracture, a spur or a smoothly curved deviation. The bony septal abnormalities were likewise divided into a fracture, a spur or a smooth deviation. The state of the bony septum was assessed purely by anterior rhinoscopy without shrinkage of the nasal mucosa. Although this did not afford an accurate assessment of the posterior septum, the usual manner of examining the nose was adopted. The importance of this decision is to assess a management policy which is readily acceptable to the clinician and not indulge in esoteric manoeuvres which will not be practiced by the majority of otolaryngologists. The presence of a caudal dislocation was noted. An airway grading was also made. This was based on the grading initially described by Ogura et al (1964).

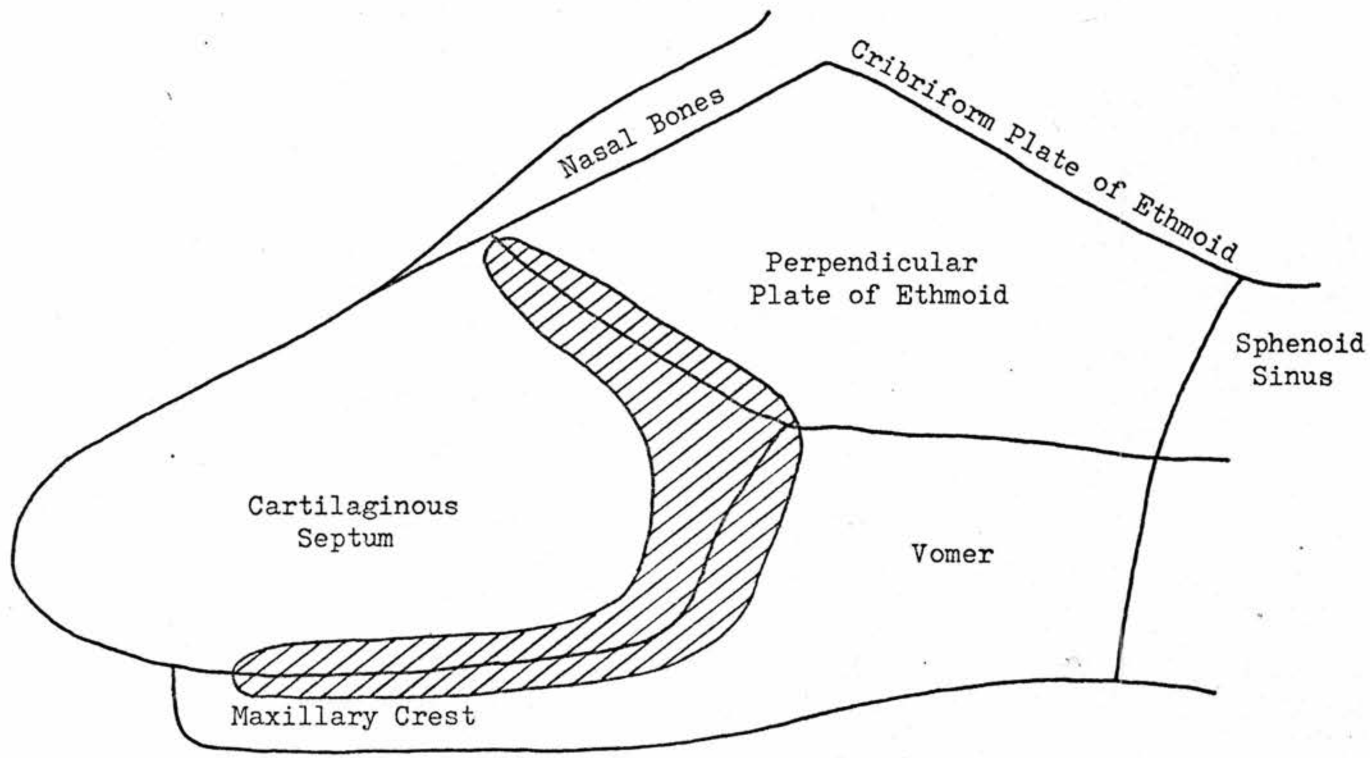
Grade 0 is a perfectly good airway, the septum is reasonably straight and the nose never blocks. Grade 1 airway blocks now and again and only on alternate sides. The septum is reasonably straight.

A Grade 2 airway blocks either one side at a time more or less permanently or both sides block temporarily at the same time. The septum may be deviated. A Grade 3 airway is essentially poor. The nose unblocks now and again only. The septum is abnormal. Total permanent nasal airway obstruction occurs in the Grade 4 nasal airway. The septum is grossly deviated and blocks both airways.

The patients were randomised to one or other operation by the order of appearance at the clinic. Randomisation was performed by The Department of Medical Computing and Statistics, Edinburgh University. A sealed envelope for each patient was opened to allocate the operation for the patient. The surgical treatment offered in this trial was either a simple nasal manipulation, the accepted modern day treatment or a manipulation with some septal work. Permission to carry out this study was granted by the Ethical Committee of the Surgical Division of the Lothian Health Board.

This septal work is, in essence, a modified septoplasty. If a caudal dislocation was present, a hemi-transfixion incision was made and mucoperichondrial flaps were elevated on both sides. Cartilage was removed linearly from immediately behind the anterior nasal spine posteriorly in a one centimetre strip above the maxillary crest to the vomer. At this point, a 1-2cm strip of bony cartilaginous septum was removed up to and including the perpendicular plate of the ethmoid to immediately underneath the nasal bones. (Fig 6.1.) Particular emphasis was placed from this latter area in view of the findings of the cadaver experiment. If there was no caudal dislocation, a further posterior Killian type of incision was made but the area of resection was the same.

Fig 6.1



AREA OF RESECTION

It has been shown in previous chapters that probably the fractured nose behaves like a tent. If a tent pole is not straight, the sides of the tent will not stand up properly. If, therefore, the area of fracture of the bony septum is not reduced or removed, the nose will not return to the midline. This area has been shown in the stress analysis experiment and the cadaver experiment to include those areas resected in this trial.

The septum, therefore, hangs straight with no influences on the eventual shape of the nasal bones. In each patient, the incision was on the right side of the septum and the operations were all carried out by the author in as similar a fashion as humanly possible.

It was thought to be unethical to leave easily treated abnormalities of the septum if they were not strictly within the lines of resection. These were, therefore, also resected but the operation was kept within the principles already stated. The mucoperichondrial flaps were replaced and the nostrils were lightly packed with half inch ribbon gauze impregnated with a tetracycline containing antibiotic ointment to minimise infection. All the patients then had a plaster of paris splint applied. An adhesive spray was used to cover the nose at first and then sellotaped strips were sequentially place overlapping down the nose to the tip. A longer figure of eight tape was applied from the forehead down the nose, round the tip and back to the forehead. Ten sheets of 4" plaster of paris were cut in a "T"shape to cover the forehead and down onto the nose. This was applied after soaking in warm water.

Once this had been moulded and dried, elastoplast in half inch strips was used to tape the plaster in place. It was found useful to stick this tape to the eyebrows. Although this may sound cruel and painful, it ensured that the splint did not fall off or was taken off by the patient before removal at a follow-up clinic.

All these patients were anaesthetised in an identical manner and intubated during the procedure. All the patients had their noses packed with quarter inch ribbon gauze soaked in a mixture of 10% cocaine hydrochloride solution and adrenaline tartrate solution for ten minutes immediately prior to the operation. The post operative course was standardised as much as possible. Those patients who had septal surgery stayed until the second day after surgery whereas the simple manipulation patients went home the day after surgery. An initial out-patient appointment one week after surgery ensured there were no untoward complications at this stage The plaster was also removed and the patients advised to wear the cast at night for one week to prevent redeviation of the nose while rolling over in bed.

A three monthly follow-up appointment was arranged. A formal assessment of the results of the operation were made at this clinic. It is accepted that a more accurate assessment could be made if the patient were assessed at six months or even better, one year but the default rate rises dramatically after three months. The timing of this assessment, is, therefore, a compromise. Those patients who did not turn up for their appointment were reminded by letter to attend. A few required to be telephoned to re-attend. The default rate by these means was nil.

Assessment of the external nasal shape at the three monthly follow-up was made by the Sister in charge of the Ear Nose and Throat Out Patient Department of The Royal Infirmary of Edinburgh. The Sister had previously been taught and tested by the author. This manoeuvre was to provide the unbiased opinion of a third party who was unaware of the operation performed.

The internal nasal examination was performed by the author, again without shrinking the nasal mucosa. The assessment was identical to the pre-operative assessment. Any deviation of the nasal bones from the midline was noted and graded as before. Depression of the nasal bones was also noted. Cartilaginous deformities i.e. a caudal dislocation, internal fracture, spur or deviation and external deviation or dorsal depression were assessed and the airway graded as before operation. The shape of the bony septum was commented on but only if it could be adequately seen as the mucosa was not shrunk down. The patients were then asked to give a self-assessment of the nose at the time compared with before injury. Their options were, much worse, slightly worse, as good as before or better than before. This was noted by the author. To facilitate comparisons of all these varying factors, each sub-division was awarded a number of points as follows:- Bony deviation, the points were awarded as for the grading system.

0. - Perfectly straight.
1. - nil to $\frac{1}{2}$ nose breadth deviated.
2. - $\frac{1}{2}$ - 1 nose breadth deviated.
3. - Greater than 1 nose breadth deviated.
4. - Deviated as to be almost touching the cheek.

A nasal bone depression was awarded one point, no points were given if this was absent. The appearance of the external cartilaginous dorsum was scored in the same way as the bones. The presence of a caudal dislocation was awarded one point. A depressed cartilaginous dorsum was awarded one point if it was slight and two points if it was gross. The presence of septal deformities were awarded one point each for a fracture, spur or deviation of either the bony or cartilaginous septum. The airway grading was scored 0-4 as it was graded. A combined total was made for each patient, the maximum total was 22. Obviously, the lower the score, the better the nose overall.

A similar total was computed for the three month follow up. An improvement score was then made. A comparison was made between the objective total as found from above and the self-assessment score.

RESULTS.

Six hundred and twenty-five patients were personally seen by the author at the nasal trauma clinic from March, 1980 to July, 1981. i.e. a seventeen month period. i.e. a referral rate of 36.8 patients per month.

The staff of the casualty department of The Royal Infirmary of Edinburgh were encouraged to refer patients to this clinic. Obviously, not every patient who had nasal trauma was seen in this clinic but the vast majority from the casualty department attended the clinic. In the time between the visit to the casualty department and the visit to the nasal trauma clinic which was held without fail on a weekly basis, the default rate was in the order of 20%. Due to the strict criteria for entry, only 59 patients were admitted to the trial: 48 (81.4%) were male and 11 (18.6%) were female. The average age was 25.5 years, average age of females was 25.8 years and the average age for males was 25.4 years.

The most common cause of the accident was assault. Twenty-five people were in this group. Twenty-two had their noses damaged while playing a sport. Six had a fall. Four were involved in a road traffic accident and 2 were in the miscellaneous group.

The randomisation was produced by The Department of Medical Computing and Statistics. This was in the form of numbered, sealed envelopes which were opened after a decision to admit the patient to the trial had been reached and the patient had agreed to the trial. An explanation of the alternatives with all the implications and possible complications were made to the patient before he was admitted to the trial.

Although the distribution of patients between the alternative operations was randomised, it is prudent to check the efficiency of this randomisation. Tables 6.1 - 6.11 include the information on this randomisation. Table 1 demonstrates the various sex ratios. Forty-eight males in the total number of 59 patients represents a significantly greater number of males in the trial than females. This is the nature of the disease.

Of the males and females, the number apportioned to either operation are statistically similar. The breakdown of the aetiological factors is shown in Table 6.2. There is no statistical difference between sport and assault as a group. Road accidents and the miscellaneous group are themselves statistically similar but there is a significant difference between the sport and assault group and the rest. There is no surgical bias in any of the aetiological groups. More noses are deviated to the right but not significantly more (Table 6.3). One must assume this preponderence is because more assault victims are punched by a right handed attacker, pushing the nasal bones to the right. Table 6.4 demonstrates a significantly high number of the patients noses were deviated to a Grade 2. The two Grade 1 noses were included only laterally in the study and are not representative of the grading of an unselected group of patients with nasal trauma. A significant number of patients had a straight external cartilaginous dorsum.

The side of deviation of the other external septums was not significant (Table 6.5). This is similar to the findings of the nasal bones. A small number of patients had a caudal dislocation but the majority did not have this deformity.

This septal deformity was mirrored in the frequency of internal cartilaginous septal fractures and spurs. A significant proportion of these patients did not have these deformities. The internal septal deviation was much more common, however, and in crude figures, just outnumbered the non-deviated septums by one. No statistical significance can be made of these figures (Tables 6.6 - 6.10).

From all the Tables comparing the percentages and 95% confidence limits in either of the two alternative operation groups, there is a good statistical distribution for all the ten features considered. Depression of the nasal bones was present in only two patients; one had a manipulation and the other had a manipulation plus septal operation. Only one patient had a depressed external cartilaginous dorsum and she had the septal operation.

An accurate opinion may not be expressed on the state of the bony dorsum as the nasal mucosa was not shrunk down. Only the gross bony septum abnormalities were obvious. One patient had a bony septal fracture, three had a bony septal spur and two had a bony septal deviation. No statistical analysis was considered for these low numbers. The nasal airways were graded as shown in Table 6.11. The majority of patients are Grades 1-3 and no bias was shown to either operation. All the patients were assessed by the author and treated by the author.

There was a good spread of days between the accident and the operations as shown in Table 6.11a. No surgical bias was shown and there was no significance in the numbers operated on at any particular time intervals. At the one-week check-ups, no complications of the operation were found.

The external assessment at three months was performed by an unbiased observer who did not know which operation had been performed. The results at the three month check-up are summarised in Tables 6.12 - 6.20. The "a" tables combine the before and after results for easy reference. The "b" tables state the significance of this comparison.

If the 95% confidence limits of the result are outwith the 95% confidence limits of the original then this is significant. Also, a comparison of the manipulation and the septal plus manipulation operation may be made. Because in all the original distribution, there is no surgical bias, the 95% confidence limits of the manipulation operation at three months may be compared with the 95% confidence limits of the septal plus manipulation operation at three months. If these lie outwith each other, the result is significant. From Tables 6.12, 6.12a and 6.12b, it is apparent that 30 patients nasal bones were successfully straightened, 20 were still pointing to the right and 9 were pointing to the left. Significantly, more straight noses result from the septal operation and significantly, less from the manipulation operation.

Similarly, there are significantly more manipulation operations responsible for those noses still deviated. The septal operation, is, therefore, significantly better than the manipulation operation at straightening the nasal bones. From Table 6.13, there are again significantly more septal operations than manipulation operations with a perfectly straight nose at three months. More patients are in the Grade 1 group as a result of their operation but it is not obvious which operation was responsible. Again, significantly more patients had moved out of Gradings 2 and 3.

It is the septal operation which is responsible for this change. No significance can be attached to either the side or the degree of external cartilaginous deviation comparing before and after the operation. (Tables 6.14, 6.14a, 6.14b, 6.15, 6.15a and 6.15b). Only one caudal dislocation remained after the operation. Three dislocations were successfully treated by manipulation and three were treated by septoplasty but there is no statistical significance in this result. (Tables 6.16, 6.16a, 6.16b).

The treatment of either an internal septal fracture or an internal septal spur did not show any statistical improvement or advantage between operations. The only minor exception to this is the significantly small percentage of the septal operations group compared with the manipulation operation of left septal spurs at the three month follow-up. (Tables 6.17, 6.17a, 6.18, 6.18a, 6.18b). The septal operations appear to deal with the right internal cartilaginous deviation satisfactorily but fails to show any statistical improvement over the manipulation operation in left internal cartilaginous deviations (Tables 6.19, 6.19a, 6.19b). From the airway grading (Tables 6.20, 6.20a, 6.20b), a significant percentage of people improved to a perfect nasal airway. The septal operation is significantly better than the manipulation operation in this grade. The manipulation operation is responsible statistically more often for the poorer airway grading results at three months than the septal operation.

A scoring system was used to compare the overall improvement or otherwise of the nose from before to after the operation. The scoring system was as follows:-

Deviation of the bones.	0-4 (Grades)
Depression of the bones.	1 if present.
Deviation of the external cartilage.	0-4 (Grades)
Depression of the dorsum.	1 if slight, 2 if gross.
Caudal dislocation.	1 if present
Internal cartilaginous septal fracture.	1 if present.
Internal cartilaginous septal spur.	1 if present.
Internal cartilaginous septal deviation.	1 if present.
Bony septal fracture.	1 if present.
Bony septal spur.	1 if present.
Bony septal deviation.	1 if present.
Airways grading	0-4 (Grades).

These were added. Obviously, the smaller the number, the better the nose. The postoperative figure was subtracted from the preoperative figure. These figures were then ranked for statistical analysis by the Mann-Whitney Test. The septoplasty group of patients were found to have a highly statistically significant bias to the higher numbers i.e. the greater improvement. The septoplasty operation, therefore, improved all the factors considerably more than the manipulation operation.

The self assessments are shown in Table 6.23. No septal operations are included in the much worse group and statistically less in the slightly worse groups. There is no difference in the operations for the same group but the septal operations are present statistically more often in the better group than are the manipulation operations.

The septal with manipulation operation is, therefore, superior in the management of the whole nose from the patient's point of view.

The objective improvement has already been expressed as the balance of the pre and post operative scores. These were noted in Table 6.21. The subjective improvements have been noted in Table 6.23. These two may not be compared, however. The objective can only assess the change from the immediate post traumatic state to the late post-operative state. The subjective assessment compares the pre-traumatic and the late post-operative state. The difference between the pre-traumatic and post-traumatic state depends on the degree of trauma.

A correlation was, however, attempted to see if the objective and subjective assessments could be linked despite the fact that different parameters were measured.

The figures in Table 6.21 must be grouped. Let figures -1, 0 and +1 be a very poor result, 2 be a less poor result and figures 3, 4, 5, 6 and 7 be an alright or better result. Table 6.24 may be constructed from these results. It has already been stated that the manipulation operation is statistically prominent in the very poor group. The amalgamation of Tables 6.23 and 6.24 gives Table 6.25. A correlation of the crude numbers of each group was made. No significance could be made at all.

$r = 0.045 \qquad r^2 = 0.002025$

$t = 0.1192 \qquad 7 \text{ D.F.} \qquad P > 0.5$

TABLE 6.1.

SEX OF PATIENTS.

	MALE	FEMALE.
Number.	48	11
% of Total.	81.4	18.6
95% Limits.	69.0 - 90.3	9.7 - 31.0
Number of Manipulations.	25	5
% of Sex.	52.1	45.5
95% Limits.	37.1 - 66.7	16.7 - 76.6
Number of Septal Operations.	23	6
% of Sex.	47.9	54.5
95% Limits.	33.3 - 62.8	23.4 - 83.3

TABLE 6.2.

CAUSE OF TRAUMA.

	Road Traffic Accidents	Sport	Assault	Falls	Others
Number.	4	22.	25	6	2
% of Total.	6.8	37.3	42.4	10.2	3.4
95% Limits	1.8 - 16.5	25.0 - 50.9	29.6 - 56.0	3.8 - 20.8	0.41 - 11.7
Number Manipulations.	2	13	10	3	2
% of Cause.	50.0	59.1	40.0	50.0	100.0
95% Limits.	6.7 -93.3	36.3 - 79.3	21.1 - 61.3	11.8 - 88.2	15.8 - 100
Number of Septal Operations.	2	9	15	3	0
% of Total.	50.0	40.9	60.0	50.0	0
95% Limits.	6.7 - 93.3	20.7 - 63.7	38.7 - 78.9	11.8 - 88.2	0 - 84.2

TABLE 6.3

PREOPERATIVE SIDE OF BONY DEVIATION.

	RIGHT	LEFT
Number.	36	23
% of Total.	61.0	39.0
95% Limits.	47.4 - 73.5	26.5 - 52.6
Number of Manipulations.	19	11
% of Side.	52.8	47.8
95% Limits.	35.5 - 69.6	26.8 - 69.4
Number of Septal Operations.	17	12
% of Side.	47.2	52.2
95% Limits.	30.4 - 64.5	30.6 - 73.2

TABLE 6.4.

PREOPERATIVE EXTENT OF BONY DEVIATION. (Grade).

	1.	2.	3.	4.
Number.	2	41	16	0
% of Total.	3.4	69.5	27.1	0
95% Limits.	0.4 - 11.7	56.1 - 80.8	16.4 - 40.3	0.0 - 6.1
Number of Manipulations.	2	20	8	0
% of Grade.	100.0	48.8	50.0	0.0
95% Limits.	15.8 - 100	32.9 - 64.9	24.7 - 75.4	0.0
Number of Septal Operations.	0	21	8	0
% of Grade.	0	51.2	50.0	0.0
95% Limits.	0.0 - 84.2	35.1 - 67.1	24.7 - 75.4	0.0

TABLE 6.5

PREOPERATIVE SIDE OF EXTERNAL CARTILAGINOUS DORSUM.

	STRAIGHT	RIGHT	LEFT
Number.	45	11	3
% of Total.	76.3	18.6	5.1
95% Limits.	63.4 - 86.4	9.7 - 31.0	1.1 - 14.2
Number of Manipulations.	22	7	1
% of Side.	48.9	63.6	33.3
95% Limits.	33.7 - 64.2	30.8 - 89.1	0.8 - 90.6
Number of Septal Operations.	23	4	2
% of Side.	51.1	36.4	66.7
95% Limits.	35.8 - 66.3	10.9 - 69.2	9.4 - 99.2

TABLE 6.6.

PREOPERATIVE EXTENT OF CARTILAGINOUS DEVIATION. (Grade).

	0.	1.	2.	3.
Number	45	1	4	9
% of Total.	76.3	17	6.8	15.3
95% Limits.	63.4 - 86.4	0.0 - 9.1	1.9 - 16.5	7.2 - 27.0
Number of Manipulations.	22	0	2	6
% of Grade.	48.9	0.0	50.0	66.7
95% Limits.	33.7 - 64.2	0.0	6.8 - 93.2	29.9 - 92.5
Number of Septal Operations.	23	1	2	3
% of Grade.	51.1	100.0	50.0	33.3
95% Limits.	35.8 - 66.3	100.0	6.8 - 93.2	7.5 - 70.1

TABLE 6.7

PREOPERATIVE PRESENCE OF CAUDAL DISLOCATION.

	YES	NO
Number.	7	52
% of Total.	11.9	88.1
95% Limits.	4.9 - 22.9	77.1 - 95.1
Number of Manipulations.	4	26
% of Dislocation.	57.1	50.0
95% Limits.	18.4 - 90.1	35.8 - 64.2
Number of Septal Operations.	3	26
% of Dislocation.	42.9	50.0
95% Limits.	9.9 - 81.6	35.8 - 64.2

TABLE 6.8.

PREOPERATIVE INTERNAL SEPTAL FRACTURE.

	NO.	RIGHT.	LEFT.
Number.	47	5 .	7
% of Total.	79.7	8.5	11.9
95% Limits.	67.2 - 89.0	2.8 - 18.7	4.9 - 23.0
Number of Manipulations.	25	2	3
% of Fracture.	53.2	40.0	42.9
95% Limits.	38.1 - 67.9	5.27 - 85.3	9.9 - 81.6
Number of Septal Operations.	22	3	4
% of Fracture.	46.8	60.0	57.1
95% Limits.	32.1 - 61.9	14.7 - 94.7	18.4 - 90.1

TABLE 6.9

PREOPERATIVE INTERNAL SEPTAL SPUR.

	NO.	RIGHT.	LEFT.
Number.	34	6	19
% of Total.	57.6	10.2	32.2
95% Limits.	44.1 - 70.4	3.8 - 20.8	20.6 - 45.6
Number of Manipulations.	16	4	10
% of Type.	47.1	66.7	52.6
95% Limits.	29.8 - 64.9	22.3 - 95.7	28.9 - 75.6
Number of Septal Operations.	18	2	9
% of Type.	52.9	33.3	47.4
95% Limits.	35.1 - 70.2	4.3 - 77.7	24.5 - 71.1

TABLE 6.10

PREOPERATIVE INTERNAL SEPTAL DEVIATION.

	NO.	RIGHT.	LEFT.
Number.	29	18	12
% of Total.	49.2	30.5	20.3
95% Limits.	35.9 - 62.5	19.2 - 43.9	11.0 - 32.8
Number of Manipulations.	15	9	6
% of Type.	51.7	50.0	50.0
95% Limits.	32.5 - 70.6	26.0 - 74.0	21.1 - 78.9
Number of Septal Operations.	14	9	6
% of Type.	48.3	50.0	50.0
95% Limits.	29.5 - 67.5	26.0 - 74.0	21.1 - 78.9

TABLE 6.11

PREOPERATIVE AIRWAY GRADING.

	0.	1.	2.	3.	4.
Number.	2	25	16	15	1
% of Total.	3.4	42.4	27.1	25.4	1.7
95% Limits.	0.4 - 11.7	29.6 - 55.9	16.4 - 40.3	15.0 - 38.4	0.0 - 9.1
Number of Manipulations.	2	14	8	6	0
% of Grade.	100.0	56.0	50.0	40.0	0
95% Limits.	15.8 - 100.0	34.9 - 75.6	24.7 - 75.4	16.3 - 67.7	-
Number of Septal Operations.	0	11	8	9	1
% of Grade.	0	44.0	50.0	60.0	100.0
95% Limits.	0.0 - 84.2	24.4 - 65.1	24.7 - 75.4	32.3 - 83.7	-

TABLE 11a.

TIME INTERVAL BETWEEN ACCIDENT AND TREATMENT IN DAYS.

	0-4	5-7	8-11	12-14	15-18	19-21	≥ 21
Number.	10	15	16	10	5	0	3
% of Total.	17.0	25.4	27.1	17.0	8.5	0	5.1
95% Limits.	8.4-29.0	15.0-38.4	16.4-40.3	8.4-29.0	2.8-18.7	0.0-6.1	1.1-14.2
Number of Manipulations.	9	6	6	5	3	0	1
% of Type.	90.0	40.0	37.5	50.0	60.0	0	33.3
95% Limits	55.5-99.8	16.3-67.7	15.2-64.6	18.7-81.3	14.7-94.7	-	0.8-90.6
Number of Septal Operations.	1	9	10	5	2	0	2
% of Type.	10.0	60.0	62.5	50.0	40.0	0	66.7
95% Limits.	0.3-44.5	32.3-83.7	35.4-84.8	18.7-81.3	5.3-85.3	-	9.4-99.2

TABLE 6.12

POSTOPERATIVE EXTERNAL BONY DEVIATION.(Side).

	STRAIGHT.	RIGHT.	LEFT.
Number	30	20	9
% of Total.	50.9	33.9	15.3
95% Limits.	37.5 - 64.1	22.1 - 47.4	7.2 - 27.0
Number of Manipulations.	6	16	8
% of Type.	20.0	80.0	88.9
95% Limits.	7.7 - 38.6	56.3 - 94.3	51.8 - 99.7
Number of Septal Operations.	24	4	1
% of Type.	80.0	20.0	11.1
95% Limits.	61.4 - 92.3	5.7 - 43.7	0.3 - 48.3

TABLE 6.12a.

	Preop. Straight.	Postop. Straight.	Preop. Right.	Postop. Right.	Preop. Left.	Postop. Left.
Number.	0	30	36	20	23	9
% of Total.	0	50.9	61.0	33.9	39.0	15.2
95% Limits.	0.0-6.1	37.5-64.1	47.4-73.5	22.1-47.4	26.5-52.6	7.2-27.0
Number of Manipulations.	0	6	19	16	11	8
% of Type.	0.0	20.0	52.8	80.0	47.8	88.9
95% Limits.	0.0-11.9	7.7-38.6	35.5-69.6	56.3-94.3	26.8-69.4	51.8-99.7
Number of Septal Operations.	0	24	17	4	12	1
% of Type.	0	80.0	47.2	20.0	52.2	11.1
95% Limits.	0.0-11.6	61.4-92.3	30.4-64.5	5.7-43.7	30.6-73.2	0.3-48.3

TABLE 6.12b.

COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER, BEFORE AND AFTER OPERATION.

	STRAIGHT	RIGHT	LEFT
Total.	Significant	Non-significant	Non-significant
% Manipulated.	Non-significant	Non-significant	Non-significant
% Septal Operations.	Significant	Non-significant	Non-significant
Comparison of % Manipulated to % Septal Operations.	Significant	Significant	Significant

TABLE 6.13.

POSTOPERATIVE EXTENT OF BONY DEVIATION.

	0.	1.	2.	3.
Number	30	13	15	1
% of Total.	50.8	22.0	25.4	1.7
95% Limits.	37.5 64.1	12.3 - 34.7	15.0 - 38.4	0.0 - 9.1
Number of Manipulations.	6	8	15	1
% of Grade.	20.0	61.5	100.0	100.0
95% Limits.	7.7 - 38.6	31.6 - 86.1	78.2 - 100.0	-
Number of Septal Operations.	24	5	0	0
% of Grade.	80.0	38.5	0	0
95% Limits.	61.4 - 92.3	13.9 - 68.4	0.0 - 21.8	-

TABLE 6.13a.

EXTENT OF BONY DEVIATION.(Grades).

	Preop - 0	Postop - 0	Preop-1	Postop-1	Preop-2	Postop-2
Number	0	30	2	13	41	15
% of Total.	0	50.9	3.4	22.0	69.5	25.4
95% Limits.	0.0 - 6.1	37.5 - 64.1	0.4 - 11.7	12.3 - 34.7	56.1 - 80.8	15.0-38.4
Number of Manipulations.	0	6	2	8	20	15
% of Grade.	0	20.0	100.0	61.5	48.8	100.0
95% Limits.	0.0 - 11.9	7.7 - 38.6	15.8 - 100	31.6 - 86.1	32.9 - 64.9	78.2 - 100
Number of Septal Operations.	0	24	0	5	21	0
% of Grade.	0	80.0	0	38.5	51.2	0
95% Limits.	0.0 - 11.6	61.4 - 92.3	0.0 - 84.2	13.9 - 68.4	35.1 - 67.1	0.0-21.8

TABLE 6.13a. (Contd).

EXTENT OF BONY DEVIATION. (Grades).

	Preop-3	Postop-3
Number.	16	1
% of Total.	27.1	1.7
95% Limits.	16.4 - 40.3	0.0 - 9.1
Number of Manipulations.	8	1
% of Grade.	50.0	100.0
95% Limits.	24.7 - 75.4	-
Number of Septal Operations.	8	0
% of Grade.	50.0	0
95% Limits.	24.7 - 75.4	-

TABLE 6.13b.

EXTENT OF BONY DEVIATION - COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	0.	1.	2.	3.
Total.	Significant	Significant	Significant	Significant
% Manipulated.	Non-significant	Non-significant	Significant	Significant
% of Septal Operations.	Significant	Non-significant	Significant	Significant
Comparison of % Manipulated to % Septal Operations.	Significant	Non-significant	Significant	-

TABLE 6.14

POSTOPERATIVE SIDE OF EXTERNAL CARTILAGINOUS DEVIATION.

	STRAIGHT.	RIGHT	LEFT.
Number	46	7	6
% of Total.	78.0	11.9	10.2
95% Limits.	65.3 - 87.7	4.9 - 22.9	3.8 - 20.8
Number of Manipulations.	21	5	4
% of Deviation.	45.7	71.4	66.7
95% Limits.	30.9 - 60.1	29.0 - 96.3	22.3 - 95.7
Number of Septal Operations.	25	2	2
% of Deviation.	54.4	28.6	33.3
95% Limits.	39.0 - 69.1	3.7 - 71.0	4.3 - 77.7

TABLE 6.14a

SIDE OF EXTERNAL CARTILAGINOUS DEVIATION.

	Preop Straight	Postop Straight	Preop Right	Postop Right
Number	45	46	11	7
% ofTotal	76.3	78.0	18.6	11.9
95% Limits.	63.4 - 86.4	65.3 - 87.7	9.7 - 31.0	4.9 - 22.9
Number of Manipulations.	22	21	7	5
% of Deviation.	48.9	45.7	63.6	71.4
95% Limits.	33.7 - 64.2	30.9 - 60.1	30.8 - 89.1	29.0 - 96.3
Number of Septal Operations.	23	25	4	2
% of Deviation.	51.1	54.4	36.4	28.6
95% Limits.	35.8 - 66.3	39.0 - 69.1	10.9 - 69.2	3.7 - 71.0

TABLE 6.14a. (Contd).

SIDE OF EXTERNAL CARTILAGINOUS DEVIATION.

	Preop Left	Postop Left
Number	3	6
% of Total.	5.1	10.2
95% Limits.	1.1 - 14.2	3.8 - 20.8
Number of Manipulations.	1	4
% of Deviation	33.3	66.7
95% Limits.	0.8 - 90.6	22.3 - 95.7
Number of Septal Operations	2	2
% of Deviation.	66.7	33.3
95% Limits.	9.4 - 99.2	4.3 - 77.7

TABLE 6.14b

SIDE OF EXTERNAL CARTILAGINOUS DEVIATION.
COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	STRAIGHT	RIGHT	LEFT.
Total.	Non-significant	Non-significant	Non-significant
% Manipulations.	Non-significant	Non-significant	Non-significant
% Septal Operations.	Non-significant	Non-significant	Non-significant
Comparison of % Manipulations to % Septal Operations.	Non-significant	Non-significant	Non-significant.

TABLE 6.15

POSTOPERATIVE EXTENT OF CARTILAGINOUS DEVIATION.(Grade).

	0.	1	2	3
Number	46	8	1	4
% of Total.	78.0	13.6	1.7	1.7
95% Limits.	65.3 - 87.7	6.0 - 25.0	0.0 - 9.1	0.0 - 9.1.
Number of Manipulations.	21	4	1	4
% of Grade.	45.7	50.0	100.0	100.0
95% Limits.	30.9 - 61.0	15.7 - 84.3	-	39.8 - 100
Number of Septal Operations.	25	4	0	0
% of Grade.	54.3	50.0	0	0
95% Limits.	39.0 - 69.1	15.7 - 84.3	-	0.0 - 60.2

TABLE 6.15a

EXTENT OF CARTILAGINOUS DEVIATION. (Grade).

	Preop-0	Postop-0	Preop-1	Postop-1
Number	45	46	1	8
% of Total.	76.3	78.0	1.7	13.6
95% Limits.	63.4 - 86.4	65.3 - 87.7	0.0 - 9.1	6.0 - 25.0
Number of Manipulations.	22	21	0	4
% of Grade.	48.9	45.7	0	50.0
95% Limits.	33.7 - 64.2	30.9 - 61.0	-	15.7 - 84.3
Number of Septal Operations	23	25	1	4
% of Grade.	51.1	54.4	100.0	50.0
95% Limits.	35.8 - 66.3	39.0 - 69.1	-	15.7 - 84.3

TABLE 6.15a (Contd)

EXTENT OF CARTILAGINOUS DEVIATION. (Grade).

	Preop-2	Postop-2	Preop-3	Postop-3
Number.	4	1	9	4
% of Total.	6.8	1.7	15.3	1.7
95% Limits.	1.9 - 16.5	0.0 - 9.1	7.2 - 27.0	0.0 - 9.1
Number of Manipulations.	2	1	6	4
% of Grade.	50.0	100.0	66.7	100.0
95% Limits.	6.8 - 93.2	-	29.9 - 92.5	39.8 - 100
Number of Septal Operations.	2	0	3	0
% of Grade.	50.0	0	33.3	0
95% Limits.	6.8 - 93.2	-	7.5 - 70.1	0.0 - 60.2

TABLE 6.15b.

EXTENT OF CARTILAGINOUS DEVIATION.
A COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	0.	1.	2.	3.
Total	Non-significant	Non-significant	Non-significant	Non-significant
% Manipulations.	Non-significant	-	-	Non-significant
% Septal Operations.	Non-significant	-	-	Non-significant
Comparison of % Manipulations to % Septal Operations.	Non-significant	Non-significant	-	Non-significant

TABLE 6.16

POSTOPERATIVE PRESENCE OF CAUDAL DISLOCATION.

	YES	NO
Number.	1	58
% of Total.	1.7	98.3
95% Limits.	0.0 - 9.1	90.9 - 100.0
Number of Manipulations.	1	29
% of Dislocation.	100.0	50.0
95% Limits.	-	36.6 - 63.4
Number of Septal Operations.	0	29
% of Dislocation.	0	50.0
95% Limits.	-	36.6 - 63.4

TABLE 6.16a.

CAUDAL DISLOCATION.

	Preop Yes	Postop Yes	Preop No	Postop No
Number	7	1	52	58
% of Total.	11.9	1.7	88.1	98.3
95% Limits.	4.9 - 22.9	0.0 - 9.1	77.1 - 95.1	90.9 - 100.0
Number of Manipulations	4	1	26	29
% of Dislocations.	57.1	100.0	50.0	50.0
95% Limits.	18.4 - 90.1	-	35.8 - 64.2	36.6 - 63.4
Number of Septal Operations.	3	0	26	29
% of Dislocations.	42.9	0	50.0	50.0
95% Limits.	9.9 - 81.6	-	35.8 - 64.2	36.6 - 63.4

TABLE 6.16b.

CAUDAL DISLOCATION COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	YES	NO
Total.	Non-significant	Non-significant.
% Manipulations.	-	Non-significant.
% Septal Operations.	-	Non-significant.
Comparison of % Manipulations to % Septal Operations.	-	Non-significant.

TABLE 6.17

POSTOPERATIVE INTERNAL SEPTAL FRACTURE.

	NO.	RIGHT	LEFT.
Number	55	1	3
% of Total.	93.2	1.7	5.1
95% Limits.	83.5 - 98.1	0.0 - 9.1	1.1 - 14.2
Number of Manipulations.	27	1	2
% of Fracture.	49.1	100.0	66.7
95% Limits.	35.4 - 63.0	-	9.4 - 99.2
Number of Septal Operations.	28	0	1
% of Fracture.	50.9	0	33.3
95% Limits.	37.1 - 64.7	-	0.8 - 90.6

TABLES 6.17a.

INTERNAL SEPTAL FRACTURE.

	Preop No	Postop No	Preop Right	Postop Right
Number	47	55	5	1
% of Total.	79.7	93.2	85	1.7
95% Limits.	67.2 - 89.0	83.5 - 98.1	2.8 - 18.7	0.0 - 9.1
Number of Manipulations	25	27	2	1
% of Fracture.	53.2	49.1	40.0	100.0
95% Limits.	38.1 - 67.9	35.4 - 63.0	5.3 - 85.3	-
Number of Septal Operations	22	28	3	0
% of Fracture.	46.8	50.9	60.0	0
95% Limits.	32.1 - 61.9	37.1 - 64.7	14.7 - 94.7	-

TABLE 6.17a. (Contd).

INTERNAL SEPTAL FRACTURE.

	Preop Left	Postop Left
Number	7	3
% of Total.	11.9	5.1
95% Limits.	4.9 - 23.0	1.1 - 14.2
Number of Manipulations.	3	2
% of Fracture.	42.9	66.7
95% Limits.	9.9 - 81.6	9.4 - 99.2
Number of Septal Operations	4	1
% of Fracture.	57.1	33.3
95% Limits.	18.4 - 90.1	0.8 - 90.6

TABLE 6.17b.

INTERNAL SEPTAL FRACTURE:
COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	NO.	RIGHT	LEFT
Total.	Non-significant	Non-significant	Non-significant
% Manipulations.	Non-significant	-	Non-significant
% Septal Operations.	Non-significant	-	Non-significant
Comparison of % Manipulations to % of Septal Operations.	Non-significant	Non-significant	Non-significant

TABLE 6.18

POSTOPERATIVE INTERNAL SEPTAL SPUR.

	NO.	RIGHT	LEFT.
Number	45	5	9
% of Total.	76.3	8.5	15.3
95% Limits.	63.4 - 86.4	2.8 - 18.7	7.2 - 27.0
Number of Manipulations.	20	2	8
% of Spur.	44.4	40.0	88.9
95% Limits.	29.6 - 60.0	5.3 - 85.3	51.8 - 99.7
Number of Septal Operations.	25	3	1
% of Spur.	55.6	60.0	11.1
95% Limits.	40.0 - 70.4	14.7 - 94.7	0.28 - 48.3

TABLE 6.18a.

INTERNAL SPUR.

	Preop	Postop	Preop	Postop
	No	No	Right	Right
Number	34	45	6	5
% of Total	57.6	76.3	10.2	8.5
95% Limits.	44.1 - 70.4	63.4 - 86.4	3.8 - 20.8	2.8 - 18.7
Number of Manipulations	16	20	4	2
% of Spur.	47.1	44.4	66.7	40.0
95% Limits .	29.8 - 64.9	29.6 - 60.0	22.3 - 95.7	5.3 - 85.3
Septal Operations.	18	25	2	3
% of Spur.	52.9	55.6	53.3	60.0
95% Limits.	35.1 - 70.2	40.0 - 70.4	4.3 - 77.7	14.7 - 94.7

TABLE 6.18a. (Contd).

INTERNAL SPUR.

	Preop Left	Postop Left
Number	19	9
% of Total.	32.2	15.3
95% Limits.	20.6 - 45.6	7.2 - 27.0
Number of Manipulations.	10	8
% of Spur.	52.6	88.9
95% Limits.	28.9 - 75.6	51.8 - 99.7
Number of Septal Operations.	9	1
% of Spur.	47.4	11.1
95% Limits.	24.5 - 71.1	0.3 - 48.3

TABLE 6.18b.

INTERNAL SEPTAL SPUR:
COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	NO.	RIGHT	LEFT
Total.	Non-significant	Non-significant	Non-significant
% Manipulations.	Non-significant	Non-significant	Non-significant
% Septal Operations.	Non-significant	Non-significant	Non-significant
Comparison of % Manipulations to % Septal Operations.	Non-significant	Non-significant	Significant.

TABLE 6.19.

POSTOPERATIVE INTERNAL SEPTAL DEVIATION.

	NO.	RIGHT	LEFT
Number	40	12	7
% of Total.	67.8	20.3	11.9
95% Limits.	54.4 - 79.4	11.0 - 32.8	4.9 - 22.9
Number of Manipulations.	13	11	6
% of Type	32.5	91.7	85.7
95% Limits.	18.6 - 49.1	61.5 - 99.8	42.1 - 99.6
Number of Septal Operations.	27	1	1
% of Type	67.5	8.3	14.3
95% Limits.	50.9 - 81.4	0.2 - 38.5	0.4 - 57.9

TABLE 6.19a

INTERNAL SEPTAL DEVIATION.

	Preop No	Postop No	Preop Right	Postop Right
Number.	29	40	18	12
% of Total.	49.2	67.8	30.5	20.3
95% Limits.	35.9 - 62.5	54.4 - 79.4	19.2 - 43.9	11.0 - 32.8
Number of Manipulations.	15	13	9	11
% of Type.	51.7	32.5	50.0	91.7
95% Limits.	32.5 - 70.6	18.6 - 49.1	26.0 - 74.0	61.5 - 99.8
Number of Septal Operations.	14	27	9	1
% of Type	48.3	67.5	50.0	8.3
95% Limits.	29.5 - 67.5	50.9 - 81.4	26.0 - 74.0	0.2 - 38.5

TABLE 6.19a. (Contd).

INTERNAL SEPTAL DEVIATION.

	Preop Left	Postop Left
Number	12	7
% of Total.	20.3	11.9
95% Limits.	11.0 - 32.8	4.9 - 22.9
Number of Manipulations.	6	6
% of Type.	50.0	85.7
95% Limits.	21.1 - 78.9	42.1 - 99.6
Number of Septal Operations.	6	1
% of Type.	50.0	14.3
95% Limits.	21.1 - 78.9	0.4 - 57.9

TABLE 6.19b.

INTERNAL SEPTAL DEVIATION:
COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	NO.	RIGHT	LEFT
Total.	Non-significant	Non-significant	Non-significant
% Manipulations.	Non-significant	Non-significant	Non-significant
% of Septal Operations.	Non-significant	Non-significant	Non-significant
Comparison of % Manipulations to % Septal Operations.	Significant	Significant	Non-significant

TABLE 6.20.

POSTOPERATIVE AIRWAY GRADING.

	0	1	2	3	4
Number	18	25	10	6	0
% of Total	30.5	42.4	17.0	10.1	0
95% Limits.	19.2 - 44.0	29.6 - 55.9	8.4 - 29.0	3.8 - 20.8	-
Number of Manipulations	4	10	10	6	0
% of Type.	22.2	40.0	100.0	100.0	0
95% Limits.	6.4 - 47.6	21.1 - 61.3	69.1 - 100.0	54.1 - 100.0	-
Number of Septal Operations.	14	15	0	0	0
% of Type	77.8	60.0	0	0	0
95% Limits.	52.4 - 93.6	38.7 - 78.9	0.0 - 30.9	0.0 - 45.9	-

TABLE 6.20a .

POSTOPERATIVE AIRWAY GRADING.

	Preop-0	Postop-0	Preop-1	Postop-1
Number	2	18	25	16
% of Total.	3.4	30.5	42.4	42.4
95% Limits.	0.4 - 11.7	19.2 - 44.0	29.6 - 55.9	29.6 - 55.9
Number of Manipulations.	2	4	14	10
% of Type.	100.0	22.2	56.0	40.0
95% Limits.	15.8 - 100	6.4 - 47.6	34.9 - 75.6	21.1 - 61.3
Number of Septal Operations.	0	14	11	15
% of Type.	0	77.8	64.0	60.0
95% Limits.	0.0 - 84.2	52.4 - 93.6	24.4 - 65.1	38.7 - 78.9

TABLE 6.20a. (Contd).

AIRWAY GRADING.

	Preop-3	Postop-3
Number	15	6
% of Total	25.4	10.1
95% Limits.	15.0 - 38.4	3.8 - 20.8
Number of Manipulations.	6	6
% of Type.	40.0	100.0
95% Limits.	16.3 - 67.7	54.1 - 100.0
Number of Septal Operations.	9	0
% of Type	60.0	0
95% of Limits.	32.3 - 83.7	0.0 - 45.9

TABLE 6.20b

AIRWAY GRADING:
COMPARISON OF PERCENTAGES OF CHANGE FROM ONE GROUP TO ANOTHER BEFORE AND AFTER OPERATION.

	0.	1.	2.	3.
Total.	Significant	Non-significant	Non-significant	Non-significant
% of Manipulations.	Non-significant	Non-significant	Non-significant	Non-significant
% of Septal Operations.	Non-significant	Non-significant	Non-significant	Non-significant
Comparison of % Manipulations to % Septal Operations.	Significant	Non-significant	Significant	Significant

TABLE 6.21.

RANKING OF THE DIFFERENCE BETWEEN THE PREOPERATIVE AND POSTOPERATIVE SCORE.

Sum	Operation	Rank	Sum	Operation	Rank.
7	S	1	2	S	25
6	M	2.5	2	S	25
6	S	2.5	2	S	25
4	S	6.3	2	M	25
4	M	6.3	2	M	25
4	M	6.3	2	M	25
4	S	6.3	1	M	40
4	S	6.3	1	S	40
4	S	6.3	1	M	40
3	S	12.5	1	M	40
3	S	12.5	1	M	40
3	S	12.5	1	M	40
3	M	12.5	1	M	40
3	S	12.5	1	S	40
3	S	12.5	1	M	40
2	S	25	1	M	40
2	S	25	1	M	40
2	S	25	0	M	52
2	S	25	0	M	52
2	S	25	0	S	52
2	S	25	0	M	52
2	S	25	0	M	52
2	S	25	0	M	52
2	M	25	0	M	52
2	S	25	0	M	52
2	S	25	0	M	52
2	S	25	0	M	52
2	S	25	0	M	52
			0	M	52
			0	M	52
			-1	M	59

TABLE 6.22

MANN-WHITNEY TEST FOR SIGNIFICANCE OF RANKED MANIPULATION AND SEPTOPLASTY SCORES.

S : 1 + 2.5 + 6.3 + 6.3 + 6.3 + 6.3 + 12.5 + 12.5 + 12.5 + 12.5 + 12.5 +
25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 +
25 + 25 + 40 + 40 + 52 = 598.3

$$\text{Expected Value} \quad T = m\left(\frac{m + n + 1}{2}\right)$$

m = septoplasty + manipulation operations.

n = manipulation operation.

$$T = 890$$

S.D. of T = 65.95

$$T - \left(\frac{\text{Expected value of T}}{\text{S.D.}}\right) = 4.12$$

This figure is greater than 1.96 which is the level of significance.

TABLE 6.23.

SELF ASSESSMENT: COMPARING BEFORE TRAUMA AND AFTER OPERATION.

	MUCH WORSE	SLIGHTLY WORSE	SAME	BETTER
Number	7	17	15	20
% of Total	11.9	28.8	25.4	33.9
95% Limits.	4.9 - 22.9	17.8 - 42.1	15.0 - 38.4	22.1 - 47.4
Number of Manipulations.	7	13	6	4
% of Type.	100.0	76.5	40.0	20.0
95% Limits	59.0 - 100	50.1 - 93.2	16.3 - 67.7	5.7 - 43.7
Number of Septal Operations.	0	4	9	16
% of Type.	0	23.5	60.0	80.0
95% Limits.	0.0 - 41.0	6.8 - 49.9	32.3 - 83.7	56.3 - 94.3

TABLE 6.24

THE OBJECTIVE RESULT OF THE TWO OPERATIONS.

	VERY POOR	POOR	SAME OR BETTER.
Number	25	19	15
% of Total	42.4	32.2	25.4
95% Limits.	29.6 - 55.9	20.6 - 45.6	15.0 - 38.4
Number of Manipulations.	22	4	4
% of Type.	88.0	21.1	26.7
95% Limits.	68.8 - 97.5	6.1 - 45.6	7.8 - 55.1
Number of Septal Operations.	3	15	11
% of Type.	12.0	79.0	73.3
95% Limits.	2.6 - 31.2	54.4 - 94.0	44.9 - 92.2

TABLE 6.25

SELF ASSESSMENT VERSUS RECORDER.(Subjective Versus Objective).

	Self Assess Much Worse	Record Very Poor	Self Assess Slightly Worse	Record Poor.
Number	7	25	17	19
% of Total	11.9	42.4	28.8	32.2
95% Limits.	4.9 - 22.9	29.6 - 55.9	17.8 - 42.1	20.6 - 45.6
Number of Manipulations	7	22	13	4
% of Type	100.0	88.0	76.5	21.1
95% Limits.	59.0 - 100.0	68.8 - 97.5	50.1 - 93.2	6.1 - 45.6
Number of Septal Operations	0	3	4	15
% of Type.	0	12.0	23.5	79.0
95% Limits.	0.0 - 41.0	2.6 - 31.2	6.8 - 49.9	54.4 - 94.0

TABLE 6.25 (Contd).

SELF ASSESSMENT VERSUS RECORDER. (Subjective Versus Objective).

	Self Assess Same or better	Record Same or better
Number	35	15
% of Total.	59.3	25.4
95% Limits.	45.8 - 71.9	15.0 - 38.4
Number of Manipulations	10	4
% of Type	28.6	26.7
95% Limits.	14.6 - 46.3	7.8 - 55.1
Number of Septal Operations.	25	11
% of Type.	71.4	73.3
95% Limits.	53.7 - 85.4	44.9 - 92.2

DISCUSSION.

An open reduction operation for acute nasal trauma is not a new idea. Many authors have extensively described the manipulation operation in conjunction with a formal septoplasty operation as being indicated in those cases of nasal trauma with septal damage.

Foman et al (1952) published an extensive paper advocating the use of rhinoplastic techniques to allow direct vision and subsequent reduction of displaced septal fragments in cases of nasal trauma.

Holt (1978) described three common septal deformities which required surgical treatment in his series of acute nasal trauma. These were a septal fracture, a dislocation from the maxillary groove and a combination fracture dislocation. Kane and Kane (1978) also published a series of forty-five cases where open reduction of an acquired septal deformity from recent nasal trauma obtained good results. These papers do not contain much hard statistical evidence.

Several authors recommend the open reduction of nasal fractures. This recommendation is also based on clinical impression (Gollom 1955, Hilger 1961, Willemot 1970, Sputh 1970, Jordan 1967, 1974, Kilner 1942, Beekhuis 1970, Aagesen et al 1954).

Marcks and Pirsig (1977) report a failure rate of 30% in 53 patients by the routine closed reduction procedure. These results take shape and function of the nose into account. However, with a septal reconstruction procedure as well as manipulation, only 1 of 17 patients had a poor result. There is a consensus that the bony pyramid unites in the line of the septum but a septal deviation may drag a well aligned bony pyramid laterally in the post operative phase (Winston 1974, Wexler 1975, Willemot 1970). Rubinstein (1956) regarded the internal deviated nasal septum as the most important feature of a traumatised nose to be corrected. He recommended abolishment of the internal stresses of the septum by complete mobilisation of the cartilage. A more logical approach to the problem of the influence of the deviated septum and the eventual alignment of the deviated nasal bones was taken by Harrison (1979).

He felt the displaced septum could not centralise owing to a ridge along the floor of the nose. He, therefore, attempted a low horizontal submucous resection of the cartilage. Of his ten cases, four had a perfect result and six were good. He believed he could palpate a fracture of the vertical plate of the ethmoid at the time of operation in all those cases of nasal trauma with septal deviation. In a further 19 patients, he, therefore, resected a lower horizontal strip as well as a vertical posterior strip of the cartilaginous septum. He reports that fifteen patients had a perfect result and four were good.

In the author's series which is similar to the operation described by Harrison, major improvements and modifications are made. The septal fractures which Harrison could palpate in every case of septal deviation associated with nasal trauma were not so readily palpable in the author's series.

Only a gross deviation could be palpated. These deviations were associated only with a gross external bony deviation. The fracture lines of the perpendicular plate of the ethmoid which were demonstrated on the cadavers were certainly not palpable.

Even with elevation of the mucoperichondrial flaps and direct vision of the perpendicular plate of the ethmoid, a definite fracture could not always be identified. A fracture of this area was inevitable with a Grade 2 or more deviation of the nasal bones in the cadaver. A deviation of the perpendicular plate of the ethmoid was, however, very common in the clinical trial and it is suggested that the majority of patients in this series suffered a greenstick fracture in this area. It should be noted that the average age of the patients in this series is 25.5 years compared with 71.1 years from the cadaver experiment. The age difference accounts for the different types of fracture found in both series but the pattern of fracture is identical.

No good controlled trial on the operations of nasal manipulation compared with a septum correcting operation combined with manipulation has been previously completed. The initial difficulty is assessment of the nose disfigurement and functional derangement. This has been overcome in this series.

The translation of these physical disabilities to a series of numbers or gradings is mandatory to allow a statistical analysis of the results. All aspects of nasal trauma were considered including a subjective assessment.

It is the author's impression that the patient's ideas of his nose both functionally and cosmetic are not in unison with the views of the observer. More emphasis should be placed on patient satisfaction than observer satisfaction. The septal operation fulfills this criterion adequately in this series.

The superiority of the manipulation plus septal operation over the manipulation only operation is obvious in many different features of the nose. No attempt was made to mould the external cartilaginous dorsum to the midline. The septal operation did not cure all the abnormalities of the septum. The results reflect this. Overall, however, despite the extra day in hospital, most patients feel more benefit from the septal procedure and forestall the subsequent inevitable proportion of patients who require cosmetic or functional nasal operation.

The time has come to cast aside those ideas from 5,000 years ago and to enter the Twentieth Century to give nasal fractures the respect they deserve.

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