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MIXED DENTITION ANTERIOR TEETH REALIGNMENT AND RELAPSE

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INTRODUCTION

The regression of realigned teeth following orthodontic correction has been a common observation. This regression of teeth may be seen in slipped contacts, drifting, and undesirable inclined plane relations, even in the most successfully treated orthodontic case. The tendency of teeth to return to their original rotated positions following alignment and removal of retentive appliances is one of the least understood problems of orthodontics.

Gottlieb (1971) described "relapse" as one of the key words in orthodontics. Others like Brain (1969), Thompson (1959), and Edwards (1970), have ventured to resect the supracrestal fibre system which they think is the causative factor of relapse tendency and they claimed successful results. Edwards (1970) further advocated this minor surgical resection to be done in the orthodontic clinic as a routine procedure to obtain a successful treatment.

In 1969, Reitan advocated early rotation to lessen relapse tendency. He felt that such early treatment will ensure stability, since there will be formation of new and stronger ligamentous fibres as the apical portion of the root completes its growth after the tooth has already been rotated to its proper position.

For this thesis, patients in mixed dentition stage with an anterior crowding problem were chosen. The aim was to align these teeth using edgewise brackets and fixed appliance and examine the relapse tendency after the removal of the appliance.
REVIEW OF LITERATURE

Chapter 1

HISTORY OF TOOTH MOVEMENTS

A. Early Tooth Movements (1700 - 1900)

Fauchard (1726) introduced the expansion arch in orthodontics, the chief function of which was to expand the dental arch. This expansion arch was variously named as bandeau, bow, long band, bandellette, etc., and was considered as one of the greatest steps in the invention of the orthodontic appliances.

Later Shangé (1841) invented the medium for the attachment of appliances to the teeth, called tooth band, of which there were two kinds. These were the adjustable clamp band which was firmly held on the tooth crown by means of a screw, and the plain or brazed band fitted on each malposed tooth and held in place by means of cement. A few years later, Farrar also used the tooth band similar to Shange's.

Eight years after Shangé's invention of the clamp band, Dwinelle and Gaines started to use a screw in tooth movement developed from Shange's invention.

Magill improved the quality and the use of the tooth band by encircling the crown with a thin ribbon of platinum, slightly overlapping the ends and uniting them by brazing. He firmly fitted the band on the tooth crown to prevent it from slipping.

Dwinelle (1848) introduced another appliance for tooth movement, the jackscrew. It consisted of a threaded steel shaft with conical head perforated for the reception of a turning tool, and a rounded nut, also of steel, with long, parallel flanges joined at their extremities in the form of fish tail. He considered this appliance to be a powerful form of mechanism for exerting force
known to mechanics. However, it was difficult to keep in position, and also expensive.

Lee and Bennett attached a washer of elliptical form with perforated ends below the head of the jackscrew and attached ligatures to the fish tail. They used this appliance for pulling the tooth instead of pushing.

Angle also adopted this jackscrew as a traction device and he called it a "traction screw".

Rubber, because of its elastic property, was used for tooth movement. Tucker (1846) introduced the rubber as an adjunct in orthodontic appliances for tooth movement.

Another adjunct used for tooth movement was the piano wire introduced by Coffin, on the account of its great elasticity. The wire was made of nickel-silver.

Kingsley (1866) introduced a semi-removable appliance called the occipital anchorage (headgear), which was used to reduce the protruded mandible and protruded upper anterior teeth.

Angle then introduced the vulcanite for the construction of a removable working plate. He felt that vulcanite material was more delicate in form than metal, which was previously used.

Angle (1886) again introduced the metal tube and soft brass wire for ligature ties. He believed that the metal tube was worthy of distinction to be classed among the history of regulating appliances because it provided a simple, compact, and ready means of attachment between bands and working appliances. (Angle, 1907)

8. Advance in Tooth Movements

(1) Removable Appliance

One of the early removable appliances used in orthodontics was Shangé's adjustable clamp band. This appliance was held in position on the tooth crown by means of the screw.

The appliance consisted of a metal ribbon with sufficient
length to encircle the crown. The screw was tightened to prevent from displacement.

Dwinelle's jackscrew was used in a similar fashion, as a removable appliance, for tooth movement, by tying ligatures on the tooth to be moved.

Angle then introduced the working plate made of vulcanite material. (Angle, 1907)

(2) **Fixed Appliance**

(a) E arch (round wire) was introduced by Angle (1907) as an expansion arch appliance to realign the crowded dentition.

The E arch was made of metal alloy bent to conform to the ideal dental arch, which was divided into three sections. These were the middle and the two end sections. The middle section was resilient, smooth, and round and was 0.030" in diameter. The two ends received the middle section and the tips of the end sections were square in shape.

In operation, the end sections were slipped into the sheaths of the bands on the teeth which was used as anchorage. The middle section lay passively in close relation with the labial and buccal surfaces of the malposed teeth. (Angle, 1907, 1913)

(b) Pin and tube was introduced by Angle in 1910. It consisted of small vertical tubes soldered to the bands, then fitted and cemented to the tooth which was to be moved. The pins were soldered on the labial arch after certain adjustments and decisions as to the placement of the pins. The inclinations of pins can be adjusted according to the operator's desired type of tooth movements. (Anderson, 1960)

(c) Ribbon arch and bracket bands (oval wire) was introduced, again by Angle, in 1915. This ribbon arch mechanism consisted of bands on individual tooth with small brackets soldered to the bands.
Then a flat piece of archwire, rectangular in shape, was fitted accurately in the brackets and locked by small pins inserted through the brackets and turned over. (Anderson, 1960)

(d) Edgewise arch mechanism was Angle’s last contribution to the mechanical side of orthodontics in 1925. (Salzman, 1957)

The edgewise archwire is a rectangular wire that came in 0.022 x 0.028" and other various sizes. This labial wire was inserted in the bracket slots and tied with ligature wires. Auxiliary attachments may be soldered in the form of stops spurs, intermaxillary hooks, vertical loops, etc., as desired on the labial archwire.

In some cases of malocclusion, round wires may be used as initial archwire and followed by rectangular archwires.

The tooth movements using this appliance were carried on by three order bends. They were the first order bend which produced labial, buccal, lingual, rotating, depressing and elongating tooth movements. The second order bend produced mesio-distal tipping of the teeth. Finally, the third order bend created root torquing. (Angle, 1929)

(e) The lightwire technique was introduced by Begg (1956) who divided the technique into three stages. The first stage involved the use of 0.016" archwire with intermaxillary hooks and anchorage bends to correct the crowding, open the bite and retract the protruded upper anterior teeth. In the second stage, the spaces were closed with the use of intramaxillary rubbers. The third stage was torquing of the roots and uprighting of the teeth.

Begg further stated, "In this technique ..... relatively lightwire and rubber ligature forces produce the most rapid movement with the least disturbance to tooth investing tissues. Also, at the same time, these light forces leave the larger rooted, posterior anchor teeth almost stationary." (Anderson, 1960; Begg, 1956)

Jarabak (1968) used a lightwire technique and claimed to be successful, but he used the edgewise brackets instead of the ribbon
brackets as used by Begg.

The initial labial wire was a round wire of size 0.016" with helical spring loops and finished with rectangular wire of 0.016 x 0.016" for torquing the roots where necessary.

C. Immediate Torsion

Immediate torsion is the method used for rotation of incisor teeth without leaving the socket by means of forceps in order to correct the irregularities of the dentition.

This method was first introduced in the late 18th century and gradually diminished in the early 20th century. The following people who have claimed success using this method are Tomes, Coleman, Spokes, Bocquet-Bull (1922, 1933), Cunningham, Colyer, Pitts, Hopewell-Smith, Macalister, Pickerill and in 1956-1957 by Hallett. (Hallett, 1955-57)

Hallett (1956-57) reported on his twenty-three cases that were successfully treated by immediate torsion. He further emphasized the use of this method in young patients with gross rotation, cleft patients and supernumerary teeth and particularly on patients who needed an immediate result.
TISSUE REACTION TO ORTHODONTIC TOOTH MOVEMENT

A. Types of Tooth Movement

(1) Tipping was considered the safest and most "biological" type of tooth movement. (Graber, 1969). This notion was probably derived from the fact that physiologic tooth movement took place mainly in the form of tipping action.

During orthodontic treatment, tipping may be in a mesio-distal direction or in labio-lingual direction, where the fulcrum is situated somewhere along the root, causing the root to move in the opposite direction to the crown.

Tipping does occur with nearly all types of orthodontic appliance used except in the edgewise technique, as claimed by Angle (1907), and in root torquing appliances.

(2) Bodily movement is another type of tooth movement implying that the root moves parallel to the inner bone surface of the alveolus. Thus both tooth crown and root are totally displaced by orthodontic treatment.

This type of tooth movement was described by Anderson (1960) as "wiggling" and "jiggling" form of movement that can be performed by the edgewise technique.

The bodily movement includes rotation, intrusion and extrusion movements.

(a) Rotation --- Reitan (Graber, 1969) mentioned that of all types of tooth movements, rotation has the greatest tendency to relapse after treatment. Thus he further advocated overrotation to minimize the problem of relapse tendency. Other operators such as Thompson (1959), Edwards (1971), Begg (1971), etc., supported Reitan's idea of relapse tendency. They agreed that the transseptal
and gingival fibres were the causative factors of relapse after rotation.

(b) Extrusion is the elongation of the tooth by orthodontic force. This type of movement is mostly done in dental openbite cases (Graber, 1969). Graber (1968) suggested that extrusion should be performed during the active growth period of the patient in order to obtain a stable result.

(c) Intrusion is a depressing tooth movement either by orthodontic force or occlusal force.

Moyers (1958) felt that intrusion was difficult and that intrusive forces had a strong tendency to occlude most of the periodontal vessels, and thus the nutrition of the membrane was impaired.

Begg (1956), however, intruded the incisor teeth routinely in his lightwire technique to open the anterior deep overbite.

Reitan (1969) and Graber (1968) have stated that successful intrusions of teeth would largely depend on the orthodontic treatment during the favourable growth period of the patient.

8. Types of Pressure

(1) Light pressure in tooth movement was considered by Begg (1956) to be about 50 to 70 gm. Begg found that this amount of pressure on the dentition during the lightwire orthodontic treatment created a maximum rate of tooth movement.

Storey and Smith (1952) reported that the optimum range of force values that produces a maximum rate of distal movement of the canines experimentally was about 150 to 200 gm. However, the molars needed 300 to 500 gm. to create a maximum rate of mesial tooth movement with least tissue damage and least pain sensation.

(2) Heavy pressure caused "undermining resorption" (Storey and
Smith, 1952) in the periodontal membrane of the tooth moved. Again in their experiment, excessive forces exerted on the canine and molar retarded their movements. Thus they concluded that orthodontic force must be within the optimum range to obtain a better result.

(3) Types of pressure related to types of tooth movement:
In tipping, there are variations in force intensity which change the fulcrum position. Oppenhein claimed that, if forces are light enough, the fulcrum is close to the apex at the apex. Heavier forces would move the fulcrum up the root towards the crown. If the application of force is near the incisal margin, the fulcrum can actually approximate the lingual crest in some instances, swinging the apex to the alveolar surface. (Stutenville, 1937)

Actually, whether the tooth movements be in the form of tipping, bodily, rotating, intruding or extruding, the soft and hard tissue reactions depend on the types of pressure exerted on the tooth.

Reitan (1960) and others have shown that, histologically, on the tension side of a tooth moved lightly, there is a stretching of periodontal fibres, and compression of periodontal fibres on the pressure side. The bone tissue on the tension side showed bone deposition. Slight bone resorption was seen on the pressure side, which immediately repaired, since it had minor tissue damage. However, when heavy pressure was exerted on the tooth, damage occurred both in the periodontal fibres and bone tissue.

The blood vessels and fibres became necrotic, and this necrosed tissue had to be removed by "undermining resorption". Thus tooth movement was held up until this necrotic tissue had been removed.

C. Force Application

(1) Intermittent force is the force that acts on the teeth either
as an impulse or shock of short duration or for a short period with a series of interruptions.

Removable appliances such as plates created this intermittent force which Reitan (1960) mentioned as the active and passive response on the teeth. If the appliance is in use, it creates an active response on the dentition and passive response if the appliance is removed. Hence, he felt that as a result of the intermittent action, there is frequently an increase in the number of cells in the periodontal membrane. This intermittent pressure may act as an irritant which in the case of a young person, often elicits formative changes. The increase in cells is largely dependent on the individual reaction to the force application.

(2) Continuous force is a steady force applied to the crown by using fixed appliances to move the teeth.

Graber (1968) reported that continuous light forces do not allow the pressure side and tension side to "recover", so, few bone-building cells are seen on the pressure side during the adjustment period. There is no osteoid bone observed on the bone surface being attacked by the osteoclasts.

However, strong continuous forces over a considerable distance are more likely to allow osteoclastic penetration of the resorption resistant cementoid layer covering the root. Thus continuous force prevents formation of both cementoid and osteoid bone at the site of greatest pressure.

D. Tissue Response

(1) Gingival response:

Atherton and Kerr (1968) have observed the triangular red patch on the mesial aspect of the tooth moved distally. This red patch was described as the enamel epithelium which had peeled off from the tooth surface.

Again Atherton (1970) had observed the clinical reaction of
the gingiva during tooth movement. There was bunching and creasing of gingival tissues on the distal aspect of the distally moving tooth.

Reitan (1959) had reported this bunching of the gingiva but associated it with the orthodontic relapse, since the subgingival fibres are resistant to changes.

Skillen (1940) suggested that the inflammatory changes of the gingiva were caused by the bands around the teeth. However, James and Beagrie (1962) felt that the neglect of oral hygiene and active periodontal disease, which was present in a proportion of cases, was not due to orthodontic treatment.

(2) Alveolar bone and periodontal ligaments (fibres):

Thompson in 1955 suggested that the reactions of connective tissue fibres are incidental to the bone changes. Thus bone is resorbed wherever there is pressure and new bone is deposited wherever there is stretching force acting upon the bone surface.

Anderson (1960) has stated that bone has only one way of responding to a gentle pressure, namely, by resorption and by compensatory new bone formation, regardless of whether the pressure upon the bone is caused by an erupting tooth, by a slowly growing cyst or tumor or by a gentle orthodontic force.

Since periodontal fibres extend from tooth cementum to alveolar bone tissue and from tooth to gingival tissue, the soft tissue is affected just as much as bone tissue in tooth movement. When a tooth is moved by orthodontic force, tension and pressure sides occur. On the tension side, the periodontal fibres are found to be stretched and compressed on the pressure side.

Reitan (1959) had reported that the collagen fibres of the periodontal membrane and subgingival tissues are distorted by tooth movement. He also has observed histologically the inclination of epithelial processes during rotation and concluded it was the result of traction by the subjacent structures.

The periodontal fibres are capable of reorganisation, and
do regenerate following orthodontic treatment and trauma. (Hurst, 1972; Chase and Revesz, 1944)

(3) Root resorption:

Becks (1942) had classified root resorption as endogenous and exogenous. Under endogenous is idiopathic root resorption; while the exogenous included infection, pressure atrophy (cyst), trauma, excessive activity and finally inactive type of root resorption.

Idiopathic root resorption was reported by Oppenheim, Ottolengui, Becks, Marshall, Mueller and others. (Steadman, 1942) Root resorption caused by orthodontic treatment will be dealt with later.

Jolly (Marshall, 1930) found in his experiment that it required $1 \frac{3}{4}$ lb. of pressure to create apical resorption of the root.

Ketcham (1929) reported in his 500 cases treated with orthodontic appliance; 21% of these cases showed root resorption after treatment.

Hemley (Steadman, 1942) also experimented on 165 cases treated with orthodontic appliances and found 21.5% to have root resorption. Others have experimented further and found some percentages of root resorption with orthodontic treatment.

Stuteville (1937) stated that root resorption is produced in 99% of all cases of malocclusion that were corrected by orthodontic appliances, but he did not mention the degree of root resorption.
Chapter 3

ORTHOdontic RELAPSE

A. Physiologic Basis of Relapse

Relapse implies the return to a former undesirable state; but the unique feature of relapse in orthodontics is that although there is a return to an undesirable state, it is not usually as it was before and is often decidedly different. (Hellman, 1944)

Huckaba (1952) considered the following factors as the physiologic basis of relapse:

(1) Statement of the problem

The problem of relapse after orthodontic treatment had faced the orthodontist from the very beginning (Hellman, 1944). He felt that satisfactory result of the case must first be accomplished before considering the retention period.

Margolis (1943) and Waldron (1942) agreed that the first requisite for prevention of undesirable post-treatment shift of the teeth is a satisfactory treatment result with the establishment of the proper relationships of the opposing teeth, and the arches with one another, as well as with the cranial base.

(2) Factors influencing the progress of treatment

Lundstrom (Huckaba, 1952) pointed out the necessity for removal of teeth in order to gain the best possible results to some orthodontic cases and his idea was supported by Tweed (1944).

Howes (Huckaba, 1952) considered over-expansion of dental arches will result in collapse of the arches.

Sved (1944), Fischer (1941) and Brodie (Huckaba, 1952) have expressed that treatment of patients must be during the active growth period, since there is an immediate improvement in facial balance.
(3) Tissue response to orthodontic tooth movement

Noyes (1942) demonstrated that there is an increase in periodontal membrane thickness on the side of tension, and decrease on the side of stress. He further explained that on the tension side, there is bone deposition and bone resorption on the pressure side in tooth movement.

Oppenheim (Huckaba, 1952) gave the warning on using heavy forces on tooth movement to prevent crushing of periodontal membrane and the occurrence of "undermining resorption".

In 1948, Litowitz had showed in his cephalometric tracing of the area of mandibular symphysis, that teeth do not move through bone. Rather, the alveolar process was remodeled as the teeth change their positions. When the teeth are more labial, the alveolar process follows; if relapse occurs, the bone returns with the teeth.

If appliances are removed before tissue reorganisation, relapse will tend to occur.

(4) Tooth position related to stability

Cole (1948) and Brodie (1938) agreed that when orthodontic manipulation causes too much change in the incisor-mandibular plane angle, balance is violated and relapse will occur.

In 1944, Tweed strongly emphasized that the ultimate facial harmony and functional occlusal balance are achieved only when the mandibular incisors are placed in an upright position over basal bone.

He further stated it is only in such position that the lower incisors are best able to resist the forces of mastication and maintain the permanence of tooth position.

Holdaway (Jarabak, 1968) gave the incisor inclination a numerical value derived from his clinical observation. The incisor teeth must not exceed 7m.m., which was measured on the line of occlusion through the apex of mandibular incisors.
(5) Natural aids to retention

Dewey and Anderson (1942) suggested the following natural aids to retention:

(a) anatomy of crown must be related to its incline plane relationship with the opposing teeth;
(b) the anterior overbite relationship must be about the incisal third of the lower incisor teeth;
(c) there must be harmony in size and relationships of the upper and lower arches;
(d) presence of good muscular balance;
(e) maintenance of close approximal contacts;
(f) the alveolar process must be in good condition;
(g) proper relationship of condylar region;
(h) there should be normal cellular activity in order to create an immediate repair action.

B. Specific Causative Factors of Relapse

(1) Periodontal ligament is the connective tissue that fills the space between the surface of the root and bony wall of the alveolus. It surrounds the root occlusally from the border of the alveolus and supports the gingiva. (Schour, 1960)

The periodontal ligament consists of collagenous fibres following a wavy course from bone to cementum, thus permitting pseudoelastic function. It accommodated slight tooth movement. The arrangement of the principal fibres is well oriented to accommodate any force to which the tooth may be subjected.

The periodontal fibres which cause relapse tendency are:

(a) The interdental fibres or transseptal fibres running just superior to alveolar crest and directly connecting the
adjacent teeth.

These fibres have convinced Erikson and his associates (1945) that the compressed transseptal fibres between the teeth, which had been approximated following an extraction, continuously prevented the tight closure of the dental contacts.

(b) The gingival fibres originating in the cementum and terminating free in the connective tissue of the gingiva.

Atherton (1970) had demonstrated the "piling-up" of gingival tissue between two orthodontically approximated teeth.

Boese (1969), Edwards (1968) and Reitan (1960) believed that the displaced gingival tissue could be the gingival fibres that coiled and bunched and were the possible cause of relapse in rotated teeth.

(c) Oxytalan fibres, as described by Fullmer and Lillie (1958) are a component of connective tissue and their function is unknown (Hurst, 1972). Oxytalan fibres (Fullmer and Lillie, 1958) may be related to the elastic fibres and it is possible that they are involved closely with the elastic properties and function of the periodontal ligament in the transseptal region.

It has been suggested that oxytalan fibres could be a special form of collagen that develop in regions of stress (Hurst, 1972). Also Edwards (1968) had shown definite relationship between the oxytalan fibres and stress, where an increase in stress caused an increase in the fibres.

(2) Oclusal interferences:

In treated cases, where teeth are free from retaining appliances, are those that can be mounted on a mechanical articulator and give a wide-range functioning and balancing incline plane relationship with force loads distributed over a maximum number of incline planes. If interferences are present, occlusal equilibration is indicated to obtain stability of occlusion. (Jarabak,
C. Methods Employed to Prevent Relapse

(1) Overrotation was advocated by Reitan (1969) and Hahn (1944).

(2) Occlusal equilibration may be done by spot grinding or full scale equilibration according to the needs of the case. In fact Jarabak (1968) advocated occlusal equilibration after three months of retentive period.

(3) Gingival and transseptal fibres resection were advocated by Boese (1969), Brain (1969), Edwards (1970) and others who claimed success in preventing relapse after treatment.

(4) Septotomy was done by Skogsborg (1932) using fissured burrs, pointed chisel and saw to slit the septums right through the root end with local anesthesia. Then he placed them under retention and claimed to be very successful.

(5) Corticotomy was employed by Kole (1959) on the cortical layer at different points to facilitate orthodontic treatment and prevent relapse. He performed this procedure on single tooth or groups of teeth, mostly in adult patients.

(6) Early treatment was advocated by Reitan (1969) to ensure stability of the dentition. He believed that formation of new and stronger ligamentous fibres as the apical portion of the root completes its growth after tooth movement would give a better result.
Chapter 4

RETENTION

Retention is the stability of the end result. It is one of the prime objectives of orthodontic treatment for without stability neither proper function nor the best in esthetics can be maintained.

Retention is required in the following circumstances:

(1) The teeth which have been moved in or through bone by orthodontic appliances often have a tendency to return to their former positions. Therefore certain cases do require retention.

(2) Occlusion is an important factor in retention. Therefore, an orthodontist should attempt to produce the best possible occlusion of the teeth.

(3) The arch form, particularly in the mandibular arch, cannot be permanently altered by appliance therapy. Therefore treatment should be aimed at maintaining, in most instances, the arch form presented by the original malocclusion.

(4) The elimination of the causes of malocclusion such as habits like thumb sucking, lip biting or tongue thrusting, should certainly aid in the retention of its correction. Therefore a proper diagnosis based on determining the cause of the malocclusion is invaluable.

(5) Overcorrection of malocclusion is a safety factor in retention. Therefore, it is well to overcorrect the various malpositions and malrelations of teeth and jaws.

(6) Corrections carried out during periods when the patients are growing are less likely to relapse. Therefore, orthodontic treatment should be instituted at the earliest
possible age.

(7) Bone and adjacent tissues must be allowed to reorganize around the newly positioned teeth for some length of time. Hence some type of retaining appliance should be used either fixed and rigid or only inhibitory in nature and not dependent upon the teeth.

(8) Placing the lower incisors upright over basal bone will result in a more stable correction of malocclusion. Therefore, attention should be directed toward the proper angulation of the mandibular incisors. (Reidel, 1960)

Mechanical retention was classified by Jarabak (1968) as fixed, semi-fixed or removable and elastic. The fixed retainer is the lower molar to molar or cuspid to cuspid lingual retainer. Removable appliances are the Hawley and Begg retainers and the elastic one is the rubber positioner.

The length of time of wearing the retainers differs from one operator to another. Begg preferred the retainer to be worn for one year; with six months wearing it full time, and another six months of wearing at night. Kingsley (Reidel, 1960) preferred two to three years retention period and so on.

It was suggested previously by Edwards (1966), Boese (1969) and others that the resectioning of supracrestal fibres will lead to stability of the tooth moved.

Skogsborg (1927), basing on his clinical experience, suggested that septotomy is the answer to permanent retention of orthodontically treated dentition. His method was objected and criticized because it had involved too much violence by slitting the septums right through near the root ends.

Kole (1959) did corticotomy on mostly adult patients
not only to correct the dental irregularities, but also to help in retention.
Chapter 5

PHOTOGRAMMETRY

Hallert (Zulqar, Burgess and Zander, 1967) defined photogrammetry as the science of measurements with the aid of photographs in order to determine geometrical data such as size, shape and position of photographed objects.

The short range photogrammetry system as described by Zulqar and his associates (1967) is based on stereoscopy, the use of pairs of photographs of the same object from two vantage points, to obtain three dimensional effect.

This photogrammetric system consisted of two components, the acquisition and evaluation components.

The acquisition component consists of a pair of Honeywell Pentax H-1-A35 m.m. cameras altered by the addition of special lenses and fiducial marks. The lenses have a fixed focus with closely matched focal lengths. The fiducial marks are small "v's" ground into frame of the film holding surface which form images on the negative and act as points of reference. An "Estar base film" specially cut and perforated by Kodak for use in these 35 m.m. cameras insures dimensional stability of the negative.

These two cameras are held in a fixed relationship to each other in a cradle. Three set screws allow them to be removed for servicing. This cradle can then be mounted on a conventional tripod or a special mount. Then simultaneous exposure of the cameras is achieved by using a split cable release. A pair of Braun electronic flashes are synchronized to the shutters to provide lighting.

The camera axes converge at a common point at the external focal point of the lenses and therefore allow greater
Fig. 1: Cradle with the two cameras held in fixed relationship to each other.

access into restricted areas such as the mouth. The negatives are later developed and kept for evaluation.

The evaluation component is the other component of the photogrammetric system. The evaluation component is a commercially available 760 Balplex Plotter. This is a projection type stereo-photogrammetric instrument using red and blue filters to separate the images.

The negatives obtained from the acquisition component are
then placed on the Balplex Plotter for evaluation.

Fig. 2: Diagram of evaluation of component showing
(A) Balplex projectors, (B) spatial model,
(C) tracing table, and (D) orthographic tracing.

The spatial model is formed by intersecting light rays
and it is viewed with red and blue filter glasses. A tracing
table, which can be moved in the x and y direction within this
spatial model, is equipped with a circular platen, with a dot
of light near its centre, which is the measuring mark. Directly
under the dot of light is a pencil chuck with which the data is
transferred from the spatial model to a sheet of "Cronar drafting
film" taped to the large table top forming an orthographic
tracing. The platen can be moved in the z direction (i.e. up and
down) by means of an elevating spindle. The elevating spindle is
connected to a dial which records changes in the height of the platen.

This photogrammetric method was employed by Nyquist and Tham (1950-1951) to make certain measurements on plaster casts, impressions, models and denture bases. Bjorn, Lundqist and Hjelmstrom (1954) also used this method to measure the volume of facial swelling. Berkowitz and Pruzansky (Zulqar, Burgess and Zander, 1967) used the stereographs to measure the changes in the size and shape of cleft palate patients.

**Modified Orthodontic Photogrammetry**

The modified orthodontic photogrammetric method is derived from the stereo-photogrammetric system.

The apparatus used in the modified orthodontic photogrammetric method is a single Pentax camera fixed on a pole. This fixed camera can be moved in a vertical direction relative to the study model to be photographed. The study model is placed on a table which situates underneath the camera.

The study model is marked with lead on the incisal edge of the incisors and on the mesio-buccal cusp tip of the first permanent molars. The photograph is then taken at a distance of 28 c.m. from the camera so as to enlarge the study model twice its original size.

The photograph developed is enlarged twice its original size in order to facilitate convenience in measurements. The measurements are directly done on the photograph using the "protractor and parallel rule". This instrument measures the distance of tooth translated and the degree of angulation of tooth movement with relation to y-axis of the coordinate system.
ORIGINAL WORK

AIM

The purpose was to align the crowded anterior teeth using edgewise brackets and fixed appliance and examine the relapse tendency after removal of the appliance.

SELECTION OF SUBJECTS

Patients were chosen who exhibited:

(a) aged between seven and eleven years old,
(b) crowding of upper or lower central and lateral incisors,
(c) unerupted permanent canines.

MATERIALS AND METHODS

Five patients, two boys and three girls, were chosen with crowded upper or lower central and lateral incisors as subjects for the experiment. Four of these had Class I molar relationships and one Class II division 1 malocclusion.

Edgewise brackets and fixed appliance were used for this experiment. Multiloop alignment archwire 0.014" was used as the initial archwire, with 0.016" diameter wire for final alignment.

In this experiment, lateral head cephalogram, DPG, full mouth intra-oral x-rays were taken. Full mouth impressions were taken before treatment, after treatment, and four weeks later. The patients did not wear any retainer after removal of the appliance.

Photographs were taken at each stage of which there are three, before and after treatment and four weeks later.
Modified orthodontic photogrammetry was used in this experiment. Study models taken at each stage were trimmed with flat base, then marked with pencil lead on the tips of the mesio-buccal cusp of the first permanent molars and incisal edge of the four incisors, then photographed with a millimeter ruler behind the study model.

The prints were enlarged to represent twice the size of the original study models.

Fig. 3: The set-up of modified orthodontic photogrammetry.

A - Distance from film to study model is 28 cm.
B - Study model.
C - Millimeter ruler.
The degree of tooth movement was measured on the prints by an instrument called the "combined protractor and parallel rule".

Fig. 4: Combined protractor and parallel rule.

The distance of tooth translation at each stage was obtained by using the coordinate system measured on the prints. The formula used was:

\[ D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \]
where,

\[ D = \text{distance translated}, \]
\[ x = \text{abscissa on the point } (x, y), \]
\[ y = \text{ordinate on the point } (x, y). \]

The patients were recalled every three weeks for adjustment and the active treatment was within four to five months.

CASE REPORTS

Patient 1

Fig. 1-a: J.H.
J.H., 11 years old girl with Class I crowding malocclusion. The upper anterior incisors were treated. Upper incisors and deciduous second molars were banded.

Fig. 1-b: Before treatment.

Observations:

(1) After treatment --- incisors alignment was satisfactory.

Fig. 1-c: Anterior view after treatment.
Fig. 1-d: Occlusal view after treatment.

(2) Four weeks later --- slight relapse observed on the upper right lateral incisor.

Fig. 1-e: Anterior view four weeks later.
Fig. 1-f: Occlusal view four weeks later.
Patient 2

Fig. 2-a: R.H.

R.H., 11 years old boy with Class I molar relationships. The upper anterior incisors were distally rotated.
Fig. 2-b: Anterior view before treatment.
Observations:

(1) After treatment — satisfactory anterior alignment with slight spacings interproximally.

Fig. 2-d: Anterior view after treatment.

Fig. 2-e: Oclusal view after treatment.
(2) Four weeks later — relapse of the central incisors may have contributed to the ugly duckling stage and spacings interproximally.

Fig. 2-f: Anterior view four weeks later.

Fig. 2-g: Occlusal view four weeks later.
Patient 3

Fig. 3-a: T.E.

T.E., 11 years old boy with Class I crowding malocclusion. The lower incisors were treated and lower deciduous cuspids were extracted before treatment.
Fig. 3-b: Anterior view before treatment.

**Observations:**

1. After treatment — satisfactory lower anterior incisors alignment.

Fig. 3-c: Anterior view after treatment.
Fig. 3-d: Occlusal view after treatment.

(2) Four weeks later --- slight relapse occurred on the lower lateral incisors.

Fig. 3-e: Anterior view four weeks later.
Fig. 3-f: Occlusal view four weeks later.
Patient 4

Fig. 4-a: K.L.

K.L., 7 years old girl with Class II division 1 malocclusion and crowded lower incisors. The lower incisors were aligned after extraction of lower deciduous cuspids.
Fig. 4-b: Anterior view before treatment.

Fig. 4-c: Occlusal view before treatment.
Observations:

(1) After treatment — lower anterior incisors were satisfactorily aligned, but there was a lingual collapse of the anterior segment as seen in the cephalometric tracing.

Fig. 4-d: Cephalometric tracing showing lingual collapse of anterior segment. The dotted line represents the position before treatment. The continuous line represents the position after treatment.

This collapse of anterior segment suggests that with extraction of lower deciduous cuspids, there is a tendency for lingual inclination of the incisor teeth which can aggravate the anterior overbite and overjet, particularly in cases of Class II division 1 malocclusion.
Fig. 4-e: Anterior view after treatment.

Fig. 4-f: Occlusal view after treatment.
(2) Four weeks later — slight relapse occurred on lower right lateral incisor.

Fig. 4-g: Anterior view four weeks later.

Fig. 4-h: Occlusal view four weeks later.
C.S., 11 years old girl with Class I crowding problem. The patient presented with missing lower deciduous cuspids and lower anterior teeth irregularities. Lower incisors were treated.
Fig. 5-b: Anterior view before treatment.

Fig. 5-c: Occlusal view before treatment.
Observations:

(1) After treatment — favourable anterior teeth alignment.

Fig. 5-d: Anterior view after treatment.

Fig. 5-e: Occlusal view after treatment.
(2) Four weeks later --- slight relapse of lower incisors observed.

Fig. 5-f: Anterior view four weeks later.

Fig. 5-g: Occlusal view four weeks later.
MODIFIED ORTHODONTIC PHOTOGRAMMETRY

The degree of tooth angulation in relation to y-axis (of the coordinate system) and the distance of tooth translation at the three stages of the experiment of each patient are shown in the following photographs:

Patient 1

Fig. 1-g: Before treatment.
Fig. 1-h: After treatment.
Fig. 1-1: Four weeks later.
Patient 2

Fig. 2-h: Before treatment.
Fig. 2-1: After treatment.
Fig. 2-j: Four weeks later.
Fig. 3-g: Before treatment.
Fig. 3-h: After treatment.
Fig. 3-1: Four weeks later.
Patient 4

Fig. 4-i: Before treatment.
Fig. 4-j: After treatment.
Fig. 4-k: Four weeks later.
Fig. 5-h: Before treatment.
Fig. 5-1: After treatment.
Fig. 5-j: Four weeks later.
### Degree of Tooth Movement in Relation to y-Axis Angulation of Coordinate System

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<th>After Treatment</th>
<th>Four Weeks Later</th>
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<td>-4°</td>
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<td>-9</td>
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<td>-9</td>
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<td>96</td>
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<td>75</td>
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<td>22</td>
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**Note:**
- The above data were obtained by using the coordinate system.
- All the above measurements were brought to the nearest degree.
# Distance of Tooth Movement in Relation to Translation

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<thead>
<tr>
<th>NAME</th>
<th>TOOTH NUMBER</th>
<th>BEFORE TREATMENT</th>
<th>AFTER TREATMENT</th>
<th>FOUR WEEKS LATER</th>
<th>BEFORE TREATMENT TO AFTER TREATMENT</th>
<th>AFTER TREATMENT TO FOUR WEEKS LATER</th>
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<tr>
<td>J. H.</td>
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<td>(10, 62)</td>
<td>(9, 61)</td>
<td>1 m.m.</td>
<td>0.7 m.m.</td>
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<td></td>
<td>L2</td>
<td>(25, 52)</td>
<td>(27, 55)</td>
<td>(26, 51)</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
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<td>L1</td>
<td>(-10, 60)</td>
<td>(-10, 59)</td>
<td>(-9, 60)</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>(-15, 45)</td>
<td>(-25, 52)</td>
<td>(-23, 51)</td>
<td>6.1</td>
<td>1.1</td>
</tr>
<tr>
<td>R. H.</td>
<td>L1</td>
<td>(10, 64)</td>
<td>(9, 59)</td>
<td>(9, 57)</td>
<td>2.5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>(26, 55)</td>
<td>(25, 55)</td>
<td>(24, 51)</td>
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<td>(24, 54)</td>
<td>(-25, 51)</td>
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<td>L1</td>
<td>(6, 57)</td>
<td>(6, 51)</td>
<td>(6, 54)</td>
<td>3</td>
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<td>(6, 48)</td>
<td>2.5</td>
<td>1</td>
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<td>(17, 44)</td>
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<tr>
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<tr>
<td>C. S.</td>
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<td>(5, 47)</td>
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<td>2.5</td>
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**Note:**
- The above data were obtained by using the coordinate system.
- All the above figures were brought to the nearest millimeter.
RESULTS

Degree of Tooth Angulation in relation to y-axis of the Coordinate System, during the various stages of the experiment

In this experiment, it was found that there was a general tendency for the treated teeth to relapse.

The greatest relapse with respect to y-axis angulation was seen in patient 3. The lower left lateral incisor was found to have relapsed by sixteen degrees (16°).

The least relapse was seen in patient 2, where no relapse was seen on the upper right lateral incisor. There was a one degree (1°) relapse of the upper right central incisor of patient 1. The lower right lateral incisors of patient 4 and patient 5 were each found to have relapsed by one degree (1°).

In patient 1, the upper left central incisor was moved by one degree (1°), but four weeks later, it was found to have moved from the original position by a further four degrees (4°). The lower right lateral incisor of patient 5 did not move, but four weeks later, it had moved by one degree (1°) from the original position.

Distance of Tooth Translation during the various stages of the experiment

Generally, there was a tendency for the tooth translated to relapse. However, there were eight teeth that moved back beyond their original positions at the end of the experiment. They were:

(1) the upper left lateral incisor of patient 1. The distance translated due to alignment was 1.8 m.m., while the distance of relapse was 2.1 m.m.

(2) the upper right central incisor of patient 1. The distance translated due to alignment was 0.5 m.m., while the distance of relapse was 0.7 m.m.
(3) the upper left lateral incisor of patient 2. The distance translated due to alignment was 0.5 m.m., while the distance of relapse was 2.1 m.m.

(4) the upper right lateral incisor of patient 2. The distance translated due to alignment was 1 m.m., while the distance of relapse was 1.6 m.m.

(5) the lower right central incisor of patient 5. The distance translated due to alignment was 0.5 m.m., while the distance of relapse was 2.1 m.m.

(6) the lower right lateral incisor of patient 5. The distance translated due to alignment was 0 m.m., while the distance of relapse was 1.6 m.m.

(7) the lower left central incisor of patient 5. The distance translated due to alignment was 1 m.m., while the distance of relapse was 2.5 m.m.

(8) the lower left lateral incisor of patient 5. The distance translated due to alignment was 1.8 m.m., while the distance of relapse was 2.5 m.m.
DISCUSSION

Summary of Findings on Relapse of Tooth in relation to y-axis Angulation of the Coordinate System

There was a general tendency for teeth moved to relapse. In the experiment, with the exception of one case, all the teeth moved have experienced relapse with respect to y-axis angulation.

The degree of relapse varied from tooth to tooth, ranging from nil to sixteen degrees (0° to 16°). Relapse generally did not result in the tooth going back to its original position. In fact, there were two teeth out of twenty in this experiment which have moved further away from their original positions four weeks later.

Summary of Findings on Relapse of Tooth in relation to Translation

In the experiment, all the teeth moved experienced relapse in translation. Of the twenty teeth, eight have actually relapsed beyond their original positions. The distance of relapse varied from tooth to tooth, ranging from 0.7 m.m. to 2.5 m.m. None of the teeth have relapsed back to their original positions.

Non-correlation in Relapse between the y-axis Angulation of the Coordinate System and Translation

The amount translated in relapse had no correlation to the amount of relapse in y-axis angulation --- even by taking tipping into account.

In the experiment, eight teeth had relapsed beyond their positions in translation. However, these eight teeth did not exhibit relapse beyond their original positions in y-axis angulation. Hence in these eight teeth, there was no correlation between translation and y-axis angulation in relapse.
The remaining teeth showed relapse of varying amount and there was no correlation between the amount of relapse in translation and that of y-axis angulation.

All the above point to the fact that translation and y-axis angulation in relapse were independent of one another. Thus, there is no correlation between translation and y-axis angulation in relapse.

**Whether Incisor Alignment in Mixed Dentition is worthwhile**

In this experiment, as discussed above, only one tooth did not exhibit any relapse in y-axis angulation, even though its relapse in translation was evident. All the remaining teeth experienced relapse in both y-axis angulation and tooth translation.

Since relapse occurred so regularly, it can therefore be considered that early alignment is not worthwhile. However, overtreatment and the use of retainers will minimize the relapse tendency.

Hahn (1944) believed that it is difficult to maintain the tooth rotated in its position, and it is equally true in this experiment (even though the complete rotation of the teeth were not measured). He felt that the periodontal fibres from the gingival border to the apical end are disturbed and there is an attempt of these fibres to retain their status, thus the teeth relapse after rotation. So, he recommended overtreatment and the use of retainers to overcome this relapse.
SUMMARY AND CONCLUSIONS

(1) Twenty teeth were aligned and appliance removed.

(2) There was a general tendency for the teeth moved to relapse, but never back to their original positions.

(3) Overtreatment of the incisors and the use of retainers are indicated to minimize the problem of relapse.

(4) It can be concluded from this experiment that the incisors alignment is not considered worthwhile during the mixed dentition stage. However, if there is any attempt to proceed with incisors alignment in mixed dentition stage, it is advisable to use the overtreatment method.

Further study could indicate how far the teeth should be overtreated to allow relapse to aligned positions.
BIBLIOGRAPHY


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<th>Author</th>
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<tr>
<td>Skogsberg, C.</td>
<td>1932</td>
<td>The Use of Septotomy (Surgical Treatment) in Connection with the Orthodontic Treatment and the value of this Method as a Proof of Walkhoff's Theory of Tension of the Bone Tissue after Regulation of Teeth. Int. J. Orthod. 18:1044-1057.</td>
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