EVALUATION AND COMPARISON OF THE EFFECTIVENESS OF PIEZOCISION AND CORTICOTOMY DURING INDIVIDUAL CANINE RETRACTION – A SPLIT MOUTH STUDY

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"EVALUATION AND COMPARISON OF THE EFFECTIVENESS OF PIEZOCISION AND CORTICOTOMY DURING INDIVIDUAL CANINE RETRACTION – A SPLIT MOUTH STUDY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. G. JAYAKUMAR, M.D.S.,** Professor, Department of Orthodontics and Dentofacial Orthopaedics, Ragas Dental College and Hospital, Chennai.

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CERTIFICATE

This is to certify that this dissertation titled **"EVALUATION AND COMPARISON OF THE EFFECTIVENESS OF PIEZOCISION AND CORTICOTOMY DURING INDIVIDUAL CANINE RETRACTION – A SPLIT MOUTH STUDY"** is a bonafide record work done by **Dr. B. N. Vineesha** under my guidance during her post graduate study period 2014-2017.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R MEDICAL UNIVERSITY,** in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY in BRANCH V** - Orthodontics and Dentofacial Orthopedics. It has not been submitted (partially or fully) for the award of any other degree or diploma.

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CONTENTS

Introduction

INTRODUCTION

The main goal of orthodontic treatment is to improve the patient's life by enhancing the dentofacial functions and esthetics. Reducing orthodontic treatment time is one of the primary goals for orthodontists as it will lead to increased patient satisfaction especially in adults.[70] Orthodontic tooth movement is caused by remodeling i.e. apposition and resorption of the alveolar bone and the factors affecting this could regulate the rate of tooth movement**.**[18]

Earlier several attempts were made to shorten the treatment time with the administration of local or systemic hormones, PTH, Thyroxine and Prostaglandins**.**[85] Certain physical approaches which include magnets, laser beams, electrical currents and ultrasound were also employed. Treatment approaches which have recently received attention involve surgical manipulation of bone using dental distraction, undermining the interseptal bone, osteotomies, corticotomy and the most recent approach being the corticision and piezocision.

In **1959, Heinrich Kole et al**. introduced a surgical procedure which involved reflection of a full thickness flap followed by removal of interdental alveolar cortical bone by performing a sub-apical osteotomy which spares the medullary bone.[54] According to him, blocks of bone moved with this procedure rather than individual teeth would reduce the risk of root resorption.

In **1990, Gantes et al.** used a surgical technique that involved circumscribing corticotomies buccally and lingually around the six maxillary anterior teeth.[36]

Wilcko and Wilcko et al. in 2001, patented their technique as "Periodontally Accelerated Osteogenic Orthodontics" (PAOO).[109] In a series of case reports, Wilcko et al stated that corticotomy performed hastens the tooth movement by increasing the bone turnover and decreasing the bone density.[105] Corticotomy makes the tooth move faster because the bone block moves with the tooth. However tooth movement after corticotomy should be considered a combination of classical orthodontic tooth movement and bone blocks containing a tooth. The velocity of orthodontic tooth movement is influenced by bone turnover, bone density and hyalinization of the PDL.[106]

Regional Acceleratory Phenomenon (RAP) was first explained by **Frost et al.** in **1983**, who pointed out that the extent of bone corticotomy and osteotomy had a correlation with the magnitude of the healing response which led to accelerated bone turnover at the surgical site.[35]

According to **Hajji et al**. the active orthodontic treatment time in patients with corticotomies was 3-4 times more rapid when compared to patients without corticotomies.[43] Additionally, **Suya et al.** and **Wilcko et al**. have indicated that orthodontic treatment can be completed in 4-9 months with corticotomies as opposed to conventional orthodontics that takes 19-30 months.[99, 110]

Although corticotomy assisted orthodontic tooth movement is quite effective and highly predictable, it is equally invasive because it requires extensive flap elevation and osseous surgery which causes post-surgical discomfort as well as various post-operative complications**.**[108]

Vercellotti and Podesta et al. proposed the use of a piezoelectric knife instead of a high speed bur to reduce the trauma but still achieve rapid tooth movement.[103] **Park and Kim et al.** introduced the corticision technique.[78] This technique is a minimally invasive alternative to create a surgical injury to the bone without reflecting the flap. This technique uses a reinforced scalpel and a mallet to go through the gingiva and the cortical bone without raising the flaps. The surgical insult was decreased and was enough to induce the Regional Acceleratory Phenomenon effect. But this technique although was innovative had certain drawbacks. Hence in **2009, Dibart et al.** described a new and minimally invasive procedure called piezocision which involved micro incisions to the gingivae buccally and use of a piezoelectric knife to decorticate the alveolar bone to initiate the RAP.[26] Healing was uneventful, no swelling, bruising or major discomfort to the patient was associated with this procedure.

Piezocision is minimally invasive and had better patient acceptance. Even though it had several advantages, certain disadvantages like risk of root damage exists as the incisions and corticotomies are done at the interradicular sites. The procedure is technique sensitive as it requires major precision to be carried out. **Nimeri et al.** in their systematic review revealed that piezocision is considered one of the best surgical approaches because it poses good periodontal response and is one of the least invasive procedures yet is a very efficient method to initiate a **Regional Acceleratory Phenomenon**.[38]

Review of Literature

REVIEW OF LITERATURE

The review of literature for this study is categorized into six groups:

1. Orthodontic tooth movement
2. Individual canine retraction
3. NiTi coil springs
4. Different methods to accelerate orthodontic tooth movement
5. Corticotomy assisted orthodontics
6. Piezocision

ORTHODONTIC TOOTH MOVEMENT

Davidovitch Z et al (1988)[23] aimed at testing the hypothesis that tissue remodeling during orthodontic tooth movement is modulated, at least in part, by factors derived from the nervous and vascular (immune) systems. Specifically, the neurotransmitters substance P (SP) and vasoactive intestinal polypeptide (VIP) and the cytokines IL-1 alpha and IL-1 beta were localized immunohistochemically in paradental tissues of cat canines that had been treated by the application of an 80 g tipping force for 1 hour to 14 days. Administration of SP and IL-1 beta to human PDL fibroblasts in vitro for 1 to 60 minutes resulted in significant increases in the levels of the intracellular "second messenger" cAMP, as well as of PGE2, a plasma membrane associated fatty acid believed to serve as a local regulator of bone cell activity.

The results tend to support the hypothesis that neurotransmitters and cytokines play a regulatory role in orthodontic force-induced alveolar bone remodeling.

S Kyomen et al (1997)[91] investigated the influences of age changes in the proliferative activity of PDL cells during experimental tooth movement in rats. Young (6-week old) and adult (14-week old) Wister strain rats were used as experimental animals. Light (10g) or heavy forces (40g) were applied to the maxillary first molars on day of 1, 3, 7 and 14. Proliferative activity of PDL cells was evaluated immunohistochemically. In the controls, cellular activity was significantly greater in the young than in the adult group. Therefore age changes substantially influence the proliferative activity of the PDL cells and subsequent tooth movement during the initial phase of tooth movement.

Ren Y et al (2003)[80] hypothesized that orthodontic procedures seem to be more time consuming in adults than in juveniles either due to delay in the initial tissue response or because slow turnover of the bone and periodontal ligament in adults. Orthodontic tooth movement were completed between two groups 30 rats, aged 6 weeks and 9-12 months, respectively. The results showed a faster initial tooth movement in juvenile than in adult animals. Besides a delay in the onset of tooth movement in adult animals, tooth movement could be equally efficient in adults once it has started.

S Henneman et al (2008) [46] introduced a theoretical model to elucidate the complex cascade of events after the application of an orthodontic force to a tooth. The strain in the matrix of the PDL and the alveolar bone immediately after force application, resulted in a fluid flow in both tissues leading to the deformation of cells. In response to the deformation, fibroblasts and osteoblasts in the PDL as well as osteocytes in the bone were activated. A combination of PDL remodeling, and the localized apposition and resorption of alveolar bone enables the tooth to move.

V. Krishnan et al (2009) [56] aimed at identifying events that affect the sequence, timing, and significance of factors that determine the nature of the biological response of each para-dental tissue to orthodontic force. In conclusion, they reported that, orthodontic tooth movement is produced by mechanical means that evoke biological responses. They suggested that mechano response and inflammation are both essential for achieving the clinical effect of tooth movement. If both mechanisms indeed unfold in unison, orthodontists might be able to accelerate the velocity of tooth movement by utilizing additional external stimuli, whether physical, chemical, or surgical.

Sarah Alansari et al (2015) [85] reported accelerating techniques can be divided into two main groups: one group stimulates upstream events to indirectly activate downstream target cells, while the other group bypasses the upstream events and directly stimulates downstream target cells. In both approaches, there is a general consensus that the rate of tooth movement is controlled by the rate of bone resorption, which in turn is controlled by osteoclast activity. Therefore, to increase the rate of tooth movement, osteoclasts should be the target of treatment.

INDIVIDUAL CANINE RETRACTION

Tweed et al (1943) [101] proposed that for minimizing anchorage loss and maximizing tooth movement efficiency, emphasized anchorage preparation as the first step in orthodontic treatment.

Staggers JA et al (1991) [97] described anchorage as being taxed twice with a two-step retraction, as opposed to once with en masse retraction, pointing out that the posterior segment is unaware of knowing how many teeth are being retracted and merely responds according to the force system involved.

Roth et al (1994)[81] recommended separate canine retraction for maximum anchorage extraction cases but did not recommend it for moderate ones.

Samuels RHA et al (1998) conducted a clinical study of space closure with nickel titanium closed coil spring and elastic modules. The study used sliding mechanics of pitting the six anterior teeth against the second bicuspid and first molars to examine rate of space closure of 100gms and 200gms nickel titanium closed coil springs. The result for three springs and elastic module were compared. The nickel-titanium closed coil spring produced a faster rate of space closure than the elastic module. The 150 and 200gms springs produced a faster rate of space closure than the elastic module or the 100gms spring. No significant difference was noted between the rates of closure for the 150gms and 200gms springs.

Proffit and Fields et al (2000)[79] recommended separate canine retraction for maximum anchorage, stating that this approach would allow the reaction force to be constantly dissipated over the large periodontal ligament area in the anchor unit. They acknowledged, however, that closing the space in two steps rather than in one would take nearly twice as long.

Andrew J Kuhlberg et al (2001) [4] described separate canine retraction as less taxing on anchorage because the two canines are opposed by several posterior teeth in the anchor unit. Among the different space closure (anterior retraction, posterior protraction, or combination) options which are available today in preadjusted mechanotherapy, sliding mechanics has gained a substantial popularity particularly after the evolution of MBT philosophy. Currently there are several commonly used methods of applying this force: these are elastic modules, elastic chain or active modules is the significant force decay over time. Niti springs have the reported advantage of giving significantly quicker and more consistent rates of space closure.

Dixon V et al (2002)[27] compared the rates of orthodontic space closure for: Active ligature, polyurethane power chain and Nickel titanium springs. Mean rates of space closure was 0.35mm/month for active ligatures, 0.58mm/month for power chain and 0.81mm/month for Niti springs, showing that Niti springs gave the most rapid rate of space closure.

Amount of force applied to the teeth:

Boester and Johnston et al (1974)[8] conducted a split-mouth study comparing space closure rates while retracting canines using retraction springs of 2, 5, 8 and 11 oz. of force (approximately 55, 140, 225, and 310 g of force).The 2-ounce force group showed significantly slower tooth movement. However, the results showed that space closure occurred at the same rate for forces from 5-11 ounces. It was suggested that within this force range, bone resorption may be occurring at a maximal rate and thus be the rate-limiting factor.

Samuels RH et al (1993)[84] compared the effect of using continuous versus intermittent forces during space closure after premolar extraction. They compared continuous light forces from 150 g nickel-titanium (Niti) closing coils to heavy intermittent forces from elastomeric ligation that started at 400 to 450 g. The results showed an average space closure of 0.19 mm per week using elastomeric ligation while closing coils provided significantly faster average space closure of 0.26 mm per week.

Nihat Kilic et al (2010)[75] investigated the effects of two different force levels on the amount of total and daily tooth movement in rabbits and to determine whether any increase in tooth movement is equal to the increase in force. Forces of approximately 20 g (group I) and 60 (group II) g (19.6 and 58.8 cN) were applied to the upper central incisors of 25 young adult (14 weeks of age) New Zealand female rabbits. The distance between the incisors was measured daily from the mid-levels of the crowns using a digital caliper for 20 days. The results of this study showed that there was a close relationship between tooth movement and force magnitude.

Brig SM Londhe et al (2010)[9] studied the efficacy of inclusion of second molar in treatment at the outset to reinforce anchorage. The study successfully quantified the anchorage loss and brought out the advantages of including second molar in treatment at the outset. Not only the anchorage loss is minimized but inclusion of second molar also helps to maximize incisor retraction and helps control angular movement of molar and incisor. Extra time required for second molar banding is well spent, as the benefits are overwhelming.

INTERVENTIONS FOR ACCELERATING ORTHODONTIC TOOTH MOVEMENT

Pharmacological agents:

Yamasaki et al (1984) [113] injected prostaglandin E1 into the gingiva of moving teeth in rats and in human subjects, resulting in rapid movement.

Verna et al (2000)[105] experimented on rats undergoing maxillary molar mesial movement, by inducing either hypothyroidism or hyperthyroidism. In rats with high bone turnover, the rate of tooth movement was increased, while it was reduced in animals with a low turnover group. Examination of histological sections from the jaws of these rats showed that root resorption had occurred in both groups, but that it was more pronounced in the low bone turnover group.

Sekhavat et al (2002)[87] had done a systemic application of misoprostol, PGE1 analog, to rats undergoing tooth movement for 2 weeks increased significantly the velocity of movement without enhancing root resorption.

Madan et al (2007)[66] had done experimental application of the hormone relaxin to rats undergoing tooth movement. Maxillary molars were moved for 2–9 days, with or without relaxin application. Tooth velocity was found to be similar in both groups. However, relaxin reduced the level of PDL organization and mechanical strength, leading to increased tooth mobility.

Physical stimuli:

Tweedle et al (1965)[105] used local application of heat to paradental tissues surrounding orthodontically treated teeth in dogs and found a relatively faster tooth movement.

Miyoshi et al (2001)[71] conducted experiments on rats which were exposed to light for 24 or 12 hrs per day for 21 days while subjected to orthodontic force during the light periods. The teeth in the 24 hrs light group presented doubling of the rates of tooth movement and bone remodeling, as compared with animals that received the force during the 12 hrs of daily darkness.

Cruz DR et al (2004)[24] studied the effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth. One half of the upper arch was considered control group (CG) and received mechanical activation of the canine teeth every 30 days. The opposite half received the same mechanical activation and was also irradiated with a diode laser emitting light at 780 nm, during 10 seconds at 20 mW, 5 J/cm2, on 4 days of each month. All patients showed significant higher acceleration of the retraction of canines on the side treated with low intensity laser therapy when compared to the control.

Limpanichkul et al W (2006)[59] tested the hypothesis that mechanical forces combined with low-level laser therapy stimulate the rate of orthodontic tooth movement. Low level laser was applied on the mucosa buccally, distally and palatally to the canine on the test side and using a pseudo-application on the placebo side. The results showed that there was no significant difference of means of the canine distal movement between the low level laser therapy side and the placebo side for any time periods. The energy density of low level laser therapy (GaAlAs) at the surface level in this study ($25J/cm^2$) was probably too low to express either stimulatory effect or inhibitory effect on the rate of orthodontic tooth movement.

Kim DH et al (2008)[53] determined whether an exogenous electric current to the alveolar bone surrounding a tooth being orthodontically treated can enhance tooth movement in human and to verify the effect of electric currents on tooth movement in a clinical aspect. The result of the amount of orthodontic tooth movement in the experimental side during 4 weeks was greater by 30% compared to that of the control side. These results suggested that the exogenous electric current from the miniature electric device might accelerate orthodontic tooth movement by one third and have the potential to reduce orthodontic treatment duration.

Showkatbakhsh R et al (2010)[92] designed a study to determine whether a pulsed electromagnetic field (PEMF) affects orthodontic tooth movement. The results with exposure to a PEMF, canine retraction was 1.57 ± 0.83 mm more than the control group and suggested that application of a PEMF can accelerate orthodontic tooth movement.

Sousa MV et al (2011)[95] evaluated the effect of low level laser irradiation on the speed of orthodontic tooth movement of canines submitted to initial retraction. A statistically significant increase in the movement speed of irradiated canines was observed in comparison with non-irradiated canines in all evaluation periods. The study concluded that the diode laser used within the protocol guidelines increased the speed of tooth movement and that this might reduce orthodontic treatment time.

Surgical methods:

Rudolf Hasler et al (1997)[82] studied the rate of movement of the maxillary canines into the healed or recent extraction alveolus of the first premolar in 22 patients of 10-27 years. On one side of the dental arch, the first premolar was extracted. After a median time of 86 days, the contralateral first premolar was extracted and the distalization of both canines started using Gjessing canine retraction springs. The canine on the recent extraction side moved faster than that on the healed side, but with some amount of tipping.

Liou EJ et al (1998)[63] conducted invivo studies using fifteen orthodontic patients (26 canines, including 15 uppers and 11 lowers) who needed canine retraction and first premolar extraction. At the time of first premolar extraction, the interseptal bone distal to the canine was undermined with a bone bur, grooving vertically inside the extraction socket along the buccal and lingual sides and extending obliquely toward the socket base. Then, a tooth-borne, custom-made, intraoral distraction device was placed to distract the canine distally into the extraction space. During the distraction, 73% of the first molars did not move mesially and 27% of them moved less than 0.5 mm mesially within 3 weeks. The study concluded that the periodontal ligament could be rapidly distracted without complications. The rapid orthodontic tooth movement through distracting the periodontal ligament cannot be emulated by current conventional orthodontic concepts and methods.

Yadav Sumit et al (2005)[111] reviewed canine distraction by corticotomy along with conventional orthodontic therapy with the help of customized distraction device. The overall treatment time was reduced by almost 5 months without any complications. The distraction device however proved to be bulky and caused discomfort to the patient.

Iseri et al (2005)[49] study consisted of 20 maxillary canines in 10 growing or adult subjects. First premolars were extracted and the canines were subjected to retraction therapy in a surgical site using a customized, rigid, tooth-borne retraction device. They moved the cuspids about 0.8 mm per day. The full retraction of the canines was achieved in a mean time of 10±2 days.

Kharkar VR et al (2010)[51] compared using two different surgical techniques: dentoalveolar distraction and periodontal distraction to bring about rapid canine retraction using an indigenously designed intra-oral distractor. Six patients were assessed for the time required for retraction, canine tipping, anchorage loss and external root resorption. The result suggested that Dentoalveolar distraction was superior to periodontal distraction in all areas of assessment.

Hu Long et al (2012)[64] in their systematic review, evaluated the effectiveness of interventions on accelerating orthodontic tooth movement. Assessed interventions were low-level laser therapy, corticotomy, electrical current, pulsed electromagnetic fields and dentoalveolar or periodontal distraction). The systematic review revealed that:

- Corticotomy is effective and safe procedure to accelerate orthodontic tooth movement.
- Low-level laser therapy was ineffective to accelerate orthodontic tooth movement.
- Current evidence does not reveal whether electrical current and pulsed electromagnetic fields are effective in accelerating orthodontic tooth movement.
- Dentoalveolar or periodontal distraction is promising in accelerating Orthodontic tooth movement but lacks convincing evidence.

CORTICOTOMY ASSISTED ORTHODONTICS

Corticotomy is a surgical technique in which only the cortical bone is cut, perforated or mechanically altered to the depth of the medullary bone, and the medullary bone remains intact. Corticotomy (selective alveolar decortication) can be effectively used to correct dentoalveolar and moderate alveoloskeletal problems. Corticotomy found to be effective in accelerating orthodontic treatment. The most important factors in the success of this technique is proper case selection and careful surgical and orthodontic treatment. Orthodontic treatment time with this technique will be reduced to one-third than the conventional orthodontics.

History of Corticotomy:

The use of corticotomy to correct malocclusion was first described in **1892** by **L.C. Brian and G. Cunningham in 1894. Bichlmayr (1931)** applied corticotomy-ostectomy to correct maxillary protrusion after extraction of first premolars.

Cunningham et al (1894)[19] first proposed the Surgically Facilitated Orthodontic Therapy (SFOT) which is a 100 year-old idea that has evoked a progression of surgical refinements designed to-

a) Accelerate orthodontic tooth movement,
b) Limit the quantity and pathologic potential of the inevitable bacterial load,
c) Enhance stability and
d) Reduce the morbidity of orthognathic alternatives.

Cohn-Stock et al (1921)[17] citing -Angle's method, removed the palatal bone near the maxillary teeth to facilitate retrusion of single or multiple teeth.

Kretz et al (1947)[55] described a procedure similar to Cunningham's, creating, in effect, a therapeutic fracture of the anterior alveolus. Their aggressive manipulation of bone contrasts sharply with modern selective alveolar decortication, a more conservative decortication designed for a proportionate response and a method which proscribes against any aggressive bone manipulation that might compromise vasculature.

Newman WG et al (1955) [74] quoted that adults, compared with young patients, possess characteristics such as reduced spongy bone, an increase in cortical bone density, a decrease in bone volume and apical displacement of the marginal bone level, which limit the usefulness of conventional orthodontic treatment. As a result, such problems as marginal bone loss, root exposure, root resorption, and prolonged treatment time often occur in cases involving adults.

Kole H et al (1959) [54] brought about decortication of the dentoalveolar process to facilitate orthodontic tooth movement. This surgery was limited to the cortex of the dental alveolus, but sub-apical decortication was embellished by extending buccal and lingual cortical plane incisions until they communicated through the sub-apical spongiosa. Gross movements with heavy orthodontic forces with active tooth movement was achieved within 6 to 12 weeks and a period of 6 to 8 months of retention offered remarkable stability.

Bell and Levy et al (1972)[6] studied “corticotomy” techniques in Macaca mulatta, with a lack of specific details combined with disparaging, but undocumented observations. They noted that it had “a destructive effect on maxillary incisors” but failed to elaborate specifically. The operated tooth borne segments were also luxated with a chisel, a procedure which even they admit may have been more proximate cause of the ischemia.

Merrill and Pedersen et al (1976)[68] claimed that selective alveolar decortications (SAD) limited to the labial alveolar cortex is a reasonable variant where the surgeon may wish to facilitate simple labial movement and wants to maintain a copious blood supply from the lingual aspect and reflection of lingual mucoperiosteal flaps for labial movement may also contribute to greater stability by producing a more dissipated therapeutic osteopenia.

Generson and Porter et al (1978) [37] applied the decortication concept to the treatment of anterior open bites. They departed from aggressive osteotomies and segment mobilization explicitly, stating that "the surgery was done from both the labial and lingual approaches. The bony cuts were made through the cortex. Marrow was able to maintain viability of the osseous segments". They cite stability and speed as advantages to their technique, and emphasized full thickness (mucoperiosteal) flaps, resecting the neurovascular bundle of the incisive canal.

Frost HM et al (1981)[35] found a direct correlation between the severity of bone corticotomy and/or osteotomy and the intensity of the healing response, leading to accelerated bone turnover at the surgical site. This was designated ― "Regional Acceleratory Phenomenon‖" (RAP), which was explained as a temporary stage of localized soft and hard-tissue remodeling that resulted in rebuilding of the injured sites to a normal state through recruitment of osteoclasts and osteoblasts via local intercellular mediator mechanisms involving precursors supporting cells, blood capillaries and lymph.

Suya et al (1991)[99] revived with "corticotomy-facilitated orthodontics" by reporting their experiences in over 300 patients. They did not connect the buccal and labial incisions, like Kole, but relied on linear interproximal decortication. The style of decortication, divots, lines or other patterns is irrelevant. Only the sum total of therapeutic trauma is significant. Only the sum total of all therapeutic "trauma" (stimuli) is significant in its inducement of osteopenia. Suya's refinement of Kole's methods had essentially set the standard for decortication procedures that followed in the modern era.

Handelman CS et al (1996)[44] described the characteristics of the anterior alveolar bone have an adverse impact on efforts to remodel bone, particularly in adult bimaxillary protrusion cases that display incompetence in lip repose. The anatomic limits set by the cortical plates of the alveolus at the level of the incisor apices act as orthodontic walls. Post treatment results showed less remodeling than desired and severe resorption has occurred when conventional orthodontic treatment was performed alone.

Skinner et al (2000)[94] stated that just Bichlmayr described a corticotomy for patients older than 16 years, to accelerate tooth movement and reduce relapse for maxillary protrusion. This was employed with canine retraction after first bicuspid extraction, by excising the buccal and lingual cortical plates at the extraction site.

Hajji SS et al (2000)[43] investigated the efficacy of a technique combining orthodontics with alveolar corticotomy and grafting as an effective treatment for class I and II malocclusions in comparison with conventional, non-surgical orthodontic non-extraction and extraction therapies. They found that there were no differences between the RAP or AOO procedure and traditional non extraction treatments, except that treatment was three to four times faster in the corticotomy assisted group and B point increased significantly due to the alveolar augmentation.

Wilcko et al (2001)[109] reported two case reports involving surgical technique which included buccal and lingual full-thickness flaps, selective partial decortication of the cortical plates, concomitant bone grafting/augmentation, and primary flap closure. The canine and premolars in this area were expanded buccally by more than 3mm and an increase in the buccolingual thickness of the overlying buccal bone. Additionally, a preexisting fenestration on the buccal of the first premolar was covered. Both of these findings lend credence to the incorporation of the bone augmentation procedure into the corticotomy surgery because this made it possible to complete the orthodontic treatment with a more intact periodontium.

Seher Sayın et al (2004)[86] evaluated the effects of rapid canine distalization on dentoalveolar tissues during the rapid distalization of canine teeth with semi rigid, individual tooth-borne distractors on 43 canine teeth in 18 (seven male and 11 female) patients who required first premolar extractions. Results showed Rapid canine distalization with the distraction of the periodontal ligament reduces the treatment time, and both the upper and lower canines can be distalized successfully in three weeks with controlled distal tipping.

Iino et al (2006)[61] published case report of adult bimaxillary protrusion treated with corticotomy-facilitated orthodontics and titanium miniplates. The maxillary first premolars and mandibular second premolars were extracted at the same time, a corticotomy was performed on the cortical bone of the lingual and buccal sides in the maxillary anterior as well as the mandibular anterior and posterior regions. Levelling was initiated immediately after the corticotomy. The extraction spaces were closed with conventional orthodontic force (approximately1N per side) with total treatment time of 1 year.

Spena R et al (2007) [96] used segmental corticotomy to enhance molar distalization. Vertical incisions were made between the roots of the first and second molars and connected by horizontal cuts beyond the apices, ending 1-2mm below the alveolar crests. Several holes were then drilled, both buccally and palatally, to create a bleeding bed for the graft. One week after surgery, molar distalization was initiated by placing 200g nickel titanium coil springs on the maxilla. The corticotomies reduced molar resistance to distal movement and eliminated the need for anterior anchorage.

Skinner et al (2008) [93] mentioned in their publication that Skogborg in 1926 divided the interdental bone, with a procedure called ―septotomy, which was later published by them and Ascher as similar procedure, claiming that it reduced treatment duration by 20-25%. These procedures were combined with Bichlmayr's procedure by Neuman who divided the inter-radicular bone and ablated a wedge of bone palatal to the incisors meant to be retracted.

Chung, Kim and Lee et al (2009)[14] introduced "speedy surgical orthodontics" in order to treat maxillary protrusion in adults using a perisegmental corticotomy, a C-palatal miniplate, and a C-palatal retractor. This involves moving a corticotomized bone block of 6 maxillary anterior teeth instead blocks of a single tooth.

Bhat et al (2012) [7] studied acceleration of orthodontic tooth movement in class I malocclusion and bimaxillary protrusion by combination of selective alveolar decortication and bone grafting surgery. Long-term improvement in the periodontium was noticed.

Corticotomy surgery provides for a periodontal ligament-mediated acceleration in tooth movement as a result of a stimulated regional acceleratory phenomenon in conjunction with the proper morphologic situation of a thin layer of bone in the direction of movement. Alveolar augmentation of labial and lingual cortical plates were used in an effort to enhance and strengthen the periodontium using bone grafting techniques, ensuring root coverage as the dental arch was expanded**.**

Assessment of corticotomy facilitated tooth movement and changes in alveolar bone:

Thickness of the alveolar bone before and after corticotomy procedure were assessed and concluded that alveolar corticotomies not only accelerates the orthodontic treatment but, also provides the advantage of increased alveolar width to support the teeth and overlying structures. This technique has several advantages, including faster tooth movement, shorter treatment time, and safer expansion of constricted arches. Enhanced post-orthodontic treatment stability and extended envelope of tooth movement.

Lei Wang et al (2009)[107] experimented on rats to assess the tissue responses in corticotomy and osteotomy assisted tooth movements. Under orthodontic tension, corticotomy assisted tooth movement produced transient resorption of bone surrounding the dental roots. The alveolar bone surrounding the dental roots passes through resorptive, replacement, and mineralization phases of recovery. The completely freed osteotomy segment produced a different bone response that more closely resembled distraction osteogenesis.

Hong et al (2011)[47] studied on beagle animal model for histologic assessment of the biological effects of PAOO. The pressure sides during teeth movement in Group I (without corticotomy-controls) showed the presence of numerous osteoclasts and a few osteoblasts surrounding the alveolar bone. The areas of discontinuous cementum and periodontal ligament (PDL) revealed a few osteoclasts, leading to a rough and irregular root surface on the pressure side.

Aboul-Ela et al *(*2011) [90] evaluated retraction of the maxillary canines by using miniscrews as anchorage, canine retraction was initiated via closed nickel-titanium coil springs by applying 150 g of force per side. The average daily rate of canine retraction was significantly higher on the corticotomy side than the control side by 2-fold during the first 2 months and decreased by third and fourth month.

Fadi Al Nahoum et al (2014)[32] evaluated the efficacy of alveolar corticotomy on orthodontic tooth movement when retracting upper canines compared with the conventional technique and to evaluate patients' pain and discomfort levels after corticotomy. A total of 30 patients (15 males and 15 females) were recruited with a mean age of 20.04±3.63 years. The space closure velocity after corticotomy was significantly faster on the experimental side than on the control side. The pain encountered during eating was high, with 50% and 30% of patients reporting severe pain at 1 and 3 days postoperatively, respectively. No significant differences were detected between the male and female patients regarding the tooth movement velocity on the experimental side. He concluded that Alveolar corticotomy increased orthodontic tooth movement and was accompanied by moderate degrees of pain and discomfort.

Selective alveolar decortications induced a localized increased turnover of alveolar spongiosa. Dramatic demineralization – remineralization phenomenon follows selective alveolar cortication.

MINIMALLY-INVASIVE CORTICOTOMIES

Historical perspective:

Park and Kim et al (2006) [78] introduced the corticision technique as a minimally invasive alternative to create surgical injury to the bone without flap reflection. This technique used scalpel and a mallet to go through the gingiva and cortical bone without raising a flap. Drawbacks of this technique is the inability to graft soft or hard tissues, repeated malleting caused dizziness after surgery. To further reduce the invasive nature of surgical irritation of bone, a device called Propel, was introduced by Propel Orthodontics, as "Alveocentesis".

Vercellotti & Podesta et al (2007)[103] introduced the use of Piezo surgery with conventional flap elevations to create an environment conducive to rapid tooth movement. These techniques are also quite invasive in nature, as they require extensive flap elevations and osseous surgery.

Mani Alikhani et al (2013)[67] performed a single center single blinded study to investigate this procedure on humans. They used a Ni-Ti closed coil spring, delivering a constant force of 100 g to distalize the maxillary canine after first premolar extraction .MOPs could reduce orthodontic treatment time by 62%.

PIEZOCISION

Dibart et al (2010)[25] developed a new minimally invasive technique known as Piezocision, which involves microincisions with selective tunneling that allows for hard and soft tissue grafting and piezoelectric incisions. The Piezocision demonstrated similar clinical outcome when compared to classic decortication approach but has the added advantages of being quick, minimally invasive, and less traumatic to the patient. This technique is quite versatile as it allows soft-tissue grafting at the time of surgery to correct mucogingival defects if needed, as well as bone grafting in selected areas by using localized tunneling.

Sequential piezocision is a novel approach to accelerated orthodontic treatment, when this procedure was first described, cuts were made simultaneously at the maxilla and the mandible. In recent years, the technique has evolved to a more staged approach, with selected areas or segments of the arch demineralized at different times during orthodontic treatment to help achieve specific results.

Mittal S.K. et al (2011) [69] stated that piezocision assisted Orthodontics is a recently introduced, minimally invasive procedure, combining micro incisions with selective tunnelling that allows hard or soft tissue grafting and piezoelectric incisions. This novel approach lead to short orthodontic treatment time, minimal discomfort, and great patient acceptance, as well as stronger periodontium.

Kim et al (2013)[114] elucidated whether a newly developed, minimally invasive procedure, piezopuncture, would be a logical modification for accelerating tooth movement in the maxilla and the mandible. The cumulative tooth movement distance was greater in the piezopuncture group than in the control group. Piezopuncture significantly accelerated the tooth movements at all observation times, and the acceleration was greatest during the first 2 weeks for the maxilla and the second week for the mandible. They concluded that results of clinical trial of piezopuncture with optimized protocols might give orthodontists a therapeutic benefit for reducing treatment duration.

Ozlem Aylıkcı and **Caglar Sakin (2014)**[5] in their case report, presented a new, minimally invasive surgical procedure “piezocision” that combines micro-incisions and localized piezoelectric surgery to achieve similar results rapidly with minimal trauma.

N Hussein Abbas et al (2016)[76] evaluated the efficiency of corticotomy-facilitated orthodontics and piezocision in rapid canine retraction. A sample of 20 patients (15-25 years old) with Class II Division 1 malocclusions were suggested extraction of the maxillary first premolars with subsequent canine retraction. The sample was divided into 2 equal groups. In the first group, one side of the maxillary arch was treated with corticotomy, and in the second group, piezocision treatment was used. The contralateral sides of both groups served as the controls. The rates of canine crown tip were greater in the experimental sides than in the control sides in both groups. Corticotomies produced greater rates of canine movement than did piezocision. Canine root resorption was greater in the control sides. They concluded that Corticotomy-facilitated orthodontics and piezocision were efficient treatment modalities for accelerating canine retraction.

Materials and Methods

MATERIAL AND METHODS

- Patient selection and preparation
- Criteria for sample selection
- Patient records
- Armamentarium
- Methodology
- Evaluation
- Radiograph evaluation

Patients who reported to the Department of Orthodontics at Ragas Dental College and Hospital, Chennai, India were screened for the study. Twenty adult patients with Class II Division 1 for correction of maxillary incisor axial inclination were selected for the study.

Inclusion criteria:

1. Patients with class II division 1 Dentoalveolar malocclusion
2. Patient with overjet >5mm requiring 1^{st} Bicuspid Extraction.
3. Both male and female patients
4. No symptoms of temporomandibular disorders.
5. Patients between the ages of 16-25yrs.
6. Patients with satisfactory periodontal health, good bone support, adequate attached gingiva.
7. Patients with good oral hygiene.

8. Not under any systemic medication.
9. Patients undergoing Dentoalveolar camouflage treatment.

Exclusion criteria:

1. Patients with severe skeletal dysplasia in transverse, vertical and sagittal direction
2. Patients with poor periodontal health.
3. Non consenting adults.
4. Patients with severe crowding.
5. Patients on medication for systemic disorders, pregnancy or steroid therapy.
6. Patients with history of previous orthodontic treatment.

The study protocol was approved by the Institutional Review Board of Ragas Dental College and Hospital institutional research ethics committee. The ethical consideration in this study was for performing corticotomy and piezocision on the same patient.

Patient records:

After the cases were screened and found suitable, written informed consent was obtained. Routine orthodontic records including case history, pre-treatment study models, extraoral and intraoral photographs, Digital lateral cephalograms and orthopantamograms were acquired before the start of the treatment, before the start of retraction and after completion of retraction.

Armamentarium:

a) Fixed appliances Roth 0.022 x 0.028 bracket system (American Orthodontics) with upper triple buccal tube(main slot , auxiliary slot and headgear tube) (Fig.1a)
b) Levelling and alignment with 0.014 and 0.016 Nickel Titanium wires
c) Individual canine retraction with 0.017x0.025 Stainless Steel archwire (standard arch form) (Fig.1b)
d) 9mm NiTi closed coil springs (GAC Sent alloy springs , USA , 150gms of force measured with Dontrix gauge, unilaterally) (Fig.1c)
e) Stainless Steel ligature (Fig.1d)
f) Dontrix gauge (Fig.1e)
g) Vernier caliper (Fig.1f)

Surgical armamentarium:

a) #701 fissure bur (Fig.3b)
b) Vicryl 4-0 suture
c) B.P blade No.15 (Fig.3c)
d) Piezo surgical knife – BS1 Insert (Fig.2b)

Methodology:

All patients included in the study required extraction of upper first bicuspids and were treated with 0.022x0.028 slot Roth appliance. In the study group the leveling and aligning was carried out until 0.017x0.025 SS wire was engaged to perform individual canine retraction. The first premolars were not-extracted till the time the retraction stage in the treatment was commenced. Maxillary arch was split between right and left sides and piezocision was done mesial and distal to the canine root on one side and corticotomy was performed similarly on the other side and individual canine retraction was started using 9mm NiTi closed coil spring (GAC springs , USA , 150gms of force measured with Dontrix gauge).

PIEZOCISION SIDE (GROUP A)

Piezocision was performed using Piezo surgical knife on the other side. Vertical incisions were made 5mm apical to the interdental papilla using BP blade 15 and using Piezotome (Fig.2a) and Piezosurgical knife – BS 1 insert (Fig.2b) microincisions were made to depth of 3 mm and width of 3mm. Vertical piezocision cuts were placed both mesial and distal to the canine at a distance of 1.5mm from the root. Piezocision cuts were placed only on the buccal side under copious saline irrigation (Sodium Chloride 0.9% w/v). The area was sutured with an interrupted loop, non resorbable Vicryl 4-0 black silk suture material. The sutures were left in place for 1 week.

CORTICOTOMY SIDE (GROUP B)

The surgery was carried out under local anesthesia (Lignox 2%A). (Fig 3a) Surgical procedure was handled by the same maxillofacial surgeon throughout the study. First premolars were extracted at the time of the surgery. Vertical incisions using BP blade no.15 (Fig.3c) were placed on the distal and mesial aspects of the canine and a full thickness flap was elevated 3mm above the apical region of the tooth to expose the underlying cortical bone. 701 fissure bur (Fig 3.b) (SS White , USA carbide cross cut fissure bur) and no.2 size round bur (SS White , USA carbide bur) mounted on a micromotor handpiece (NSK , RPM 10000-15000) under copious amount of irrigation with saline (Sodium Chloride 0.9% w/v) was used for selective alveolar decortication. Punch hole perforations were placed in the area, stopping 2mm short of the alveolar crest, occlusally. Vertical corticotomy cuts were placed on buccal bone and palatal shelves after the periosteal tissue elevation. Buccally, the vertical cuts were placed with 2mm depth, mesial and distal to the canine tooth. The horizontal distance from the tooth proper was maintained at 1.5mm to prevent any root damage. Palatally, a similar protocol was followed with vertical cuts and horizontal distance from the tooth was maintained. Apical to the tooth a horizontal cut was placed 2mm away from the radiographically determined apex. To further improve the vascularity of the Regional Acceleratory phenomenon, semicircular perforations were placed on the cortical bone covering the root of the canine only on the buccal side.

The cuts extend only into the superficial aspect of the medullary bone to just enhance bleeding for the RAP to occur. The area was sutured with an interrupted loop, non resorbable vicryl 4-0 black silk suture material. The sutures were left in place for 1 week.

Initiation of orthodontic force was done on the same day of the intervention with the help of 9mm NiTi closed coil spring which was engaged from the first molar tube to the hook/power arm of the canine delivering a force of 150gms for individual canine retraction on both the sides ; Group A and Group B.

Retraction was checked every 2 weeks for distortion of the coil spring and immediately replaced if distorted.

Initial measurements were done after extraction using a Vernier caliper (Fig.1f) from the maximum contour of the mesial point of second premolar to the distal maximum contour of the canine.

Digital Lateral cephalograms and Orthopantamograms were taken with standardization jig (Fig 4) placed on the upper and lower first molars before retraction. Study models were taken at monthly intervals and the radiographic records were taken every 2 month to assess the treatment time, period of accelerated tooth movement, anchorage control and soft and hard tissue changes.

Evaluation:

Impressions were made with alginate and casts were made at various time periods

M0- at the time of extraction

M1- after 1 month

M2- after 2 months

M3- after 3 months

Lateral cephalograms were taken before retraction using standardized jigs which were made of 0.017x0.025 SS wire bent into an L shape, with the horizontal arm cinched close to the buccal tube and to differentiate between the right and the left side the length of the arm differed 6, 8 mm respectively. (Fig 4)

Study models were taken at monthly intervals to assess the treatment time, period of accelerated tooth movement, anchorage control and soft and hard tissue changes.

Methodology for evaluation of extraction space closure in the dental cast:

Initial measurements were done after extraction using a digital Vernier caliper at the maximum contour of the mesial point of second premolar and the distal maximum contour of the canine on the study models taken at the end of every month interval. Space closure was later co-related with the molar anchor loss values using 3D virtual models and rate of canine retraction was calculated.

Methodology for evaluation of retraction and anchor loss:

In the maxilla the linear measurements was taken from pterygoid vertical along the Frankfort horizontal plane. The horizontal distance from pterygoid vertical to the jig on the molar was used to assess anchorage loss on both sides.[100]

Methodology for evaluation of Inter-Canine and Inter-Molar width:

The Inter-canine and Inter-molar widths were measured before and after retraction in the 3-Dimensional scanned digital models between the cusp tips of canine and the mesiobuccal cusp tips of the 1^{st} molars.[98]

Methodology for evaluation of Canine angulation:

The canine angulation was measured before and after treatment in both the experimental groups. The measurements were made on the panoramic radiograph by constructing a reference plane with the stable landmark from Orbitale – Orbitale and the angulation of canines were calculated before and after retraction and compared between both the groups. [42]

Methodology for evaluation of Canine rotation:

The canine rotation was measured before and after treatment in both the experimental groups. The measurements were made on the 3-Dimensional models by a line passing through the mesial and distal contact points of the canine and bisecting line passing through the median palatal raphae and the rotation of canine was calculated before and after retraction and compared between the groups.[3]

STATISTICAL ANALYSIS

All data were entered and analyzed using SPSS Version 20 (IBM, IL, USA). The predictor variables were the Type of Intervention, Angle and Side of intervention and the Outcome variables were the tooth movement into the extraction space at various time intervals depicted as M1, M2 and M3. From this data, rate of movement was calculated.

For each variable derived the mean and the standard deviation were calculated using Descriptive statistics.

Non-parametric Tests: Mann Whitney 'U' test and Kruskal-Wallis tests were used to determine statistical significance of difference between the rates of retraction, rate of individual canine retraction in the maxilla, molar anchor loss before retraction (M0) and after retraction (M3) between both the experimental groups. p value < 0.05 was considered statistically significant.

CONSENT FORM

I, ………………………………………………………….. f/o, m/o, g/o……………………………………………, aged about………. years, Hindu/Christian/Muslim/ ………………………………….residing at ……………………………………………………………………………………
…………, do hereby solemnly and state as follows.

I am the parent/guardian of the deponent herein; as such I am aware of the facts stated here under.

I state that I brought my child……………………………………………………………..to Ragas Dental College and Hospital, Chennai for treatment.

The patient was examined by Dr……………………………….. and was requested to do the following :

1. Digital cephalogram
2. Digital OrthoPantomoGram
3. Alginate impressions (upper and lower arch) – study models
4. Multibonded fixed appliance therapy with extraction of upper first bicuspids followed by two interventions (Piezocision and Corticotomy) in the upper arch.

- The child and I were informed and explained about the pros and cons of the treatment in the ………………………………………. language known to me.
- The importance of the present treatment in relation to the overall health and development has been explained to the child and to me.

- We have also been assured that the same standard of therapeutic quality will be administered to me should I choose to not accept participation in the study protocol.
- I assure that we shall come for each and every sitting without fail.
- I authorize the doctor to proceed with further treatment or any other/suitable/alternative method for the study.
- I have given voluntary consent to undergo treatment without any individual pressure or duress.
- I am also aware that I am free to withdraw the consent given at any time during the study in writing

----

Signature of the parent/guardian

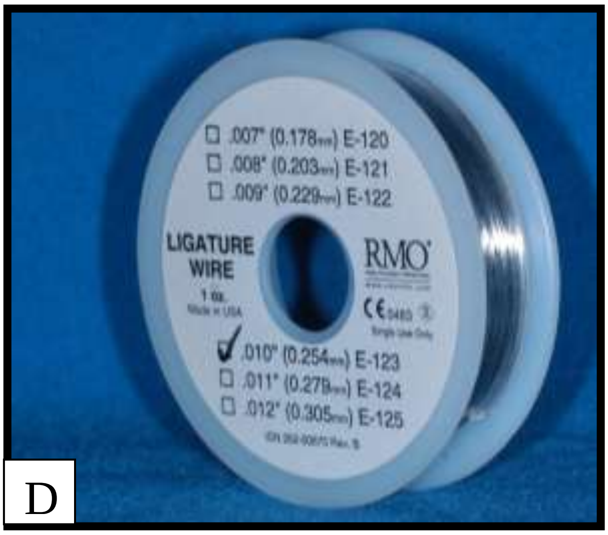
The patient and the parent/guardian/teacher was explained the procedure by me and he/she has understood the same and signed in (English/Tamil/Hindi/Telugu/…………………………………….) before me.

Signature of the Doctor

Date

Figures

Figure 1. ARMAMENTARIUM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.008" (0.203mm) E-121
.009" (0.229mm) E-122
LIGATURE
WIRE
1 oz.
RMO
.010" (0.254mm) E-123
.011" (0.278mm) E-124
.012" (0.305mm) E-125

D


sds Ormco
CE
ETM

E


STAINLESS
HARDENED

F

Figure 2a. PIEZOTOME

Figure 2b. BS1 INSERT

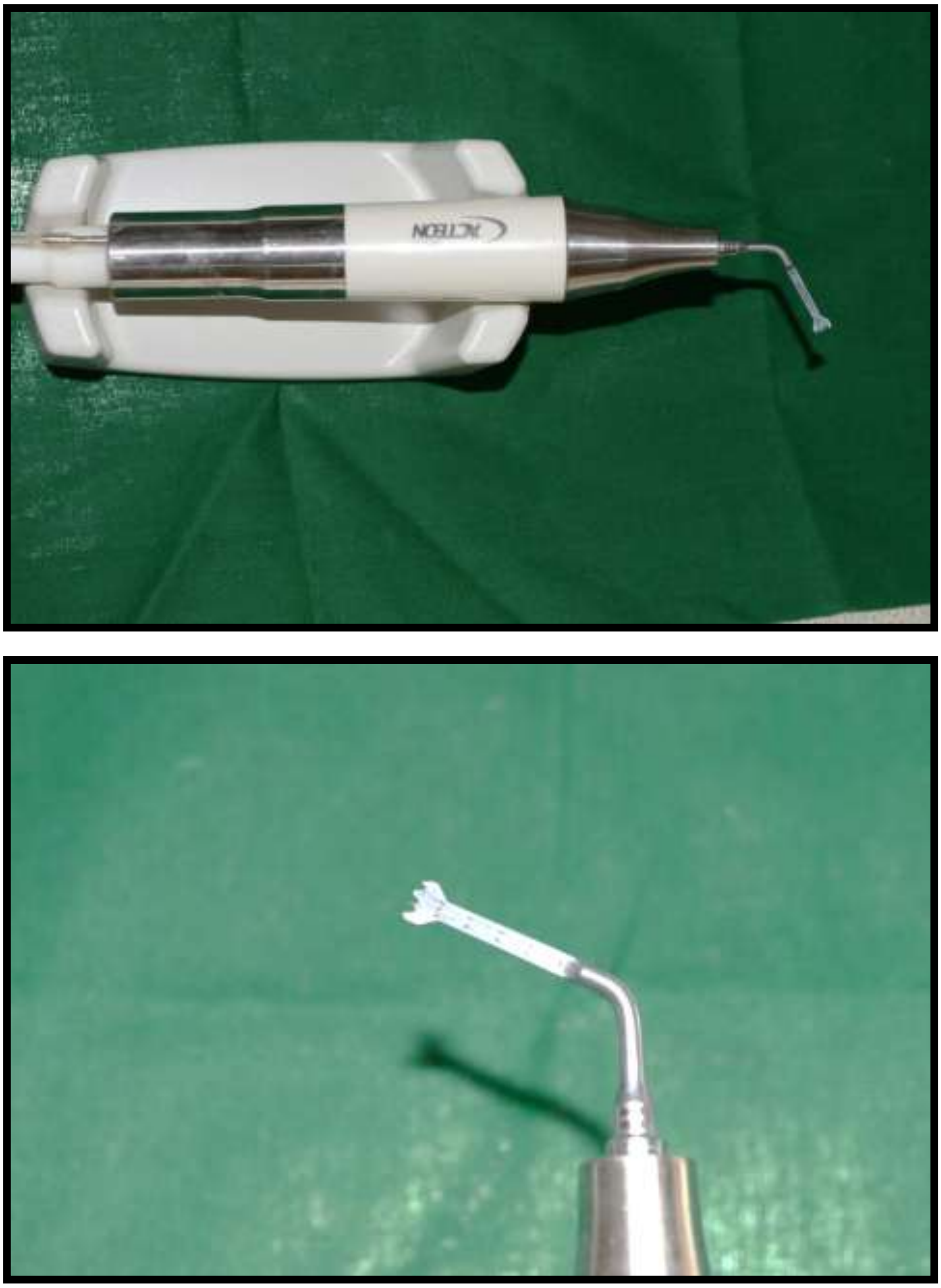
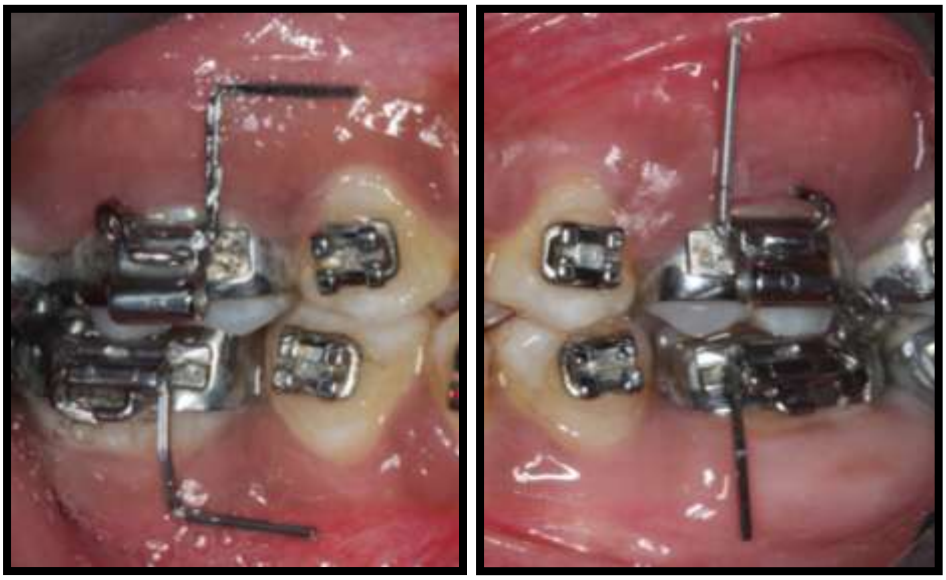
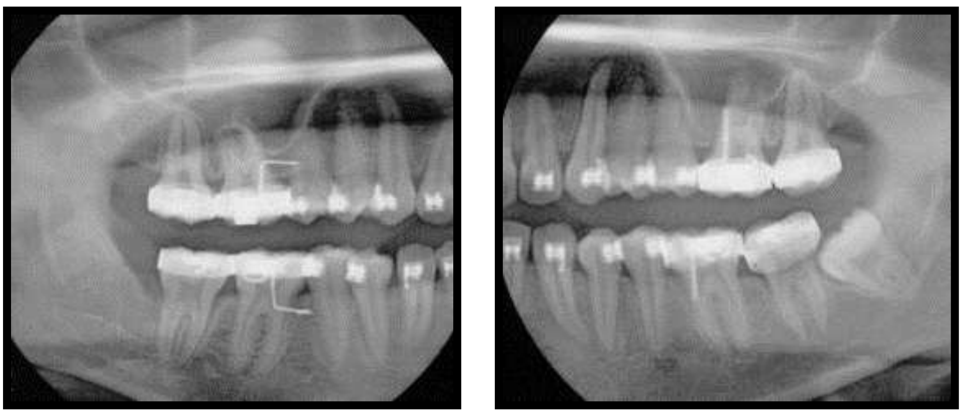


Figure 3. ARMAMENTARIUM

Figure 4. REFERENCE JIGS





Results

RESULTS

The study was conducted to evaluate and compare the effectiveness of piezocision and corticotomy during Individual Canine retraction - A Split Mouth Study in Class II Division 1 patients. The results are based on 8 patients divided into two experimental groups; Group A (Piezocision, N = 8) and Group B (Corticotomy, N = 8) on the other side in the age range of 18 years ± 4 years. All patients were selected from the patients who reported to the Department of Orthodontics at Ragas Dental College and Hospital, Chennai, India, between January and June 2016.

Descriptive statistics was carried out to statistically to determine the rate of space closure in the study group, with comparison of the data from the control group. The results are discussed under the following headings:

COMPARISON OF ACTUAL AND DERIVED TOOTH MOVEMENT IN BOTH THE EXPERIMENTAL GROUPS AT VARIOUS INTERVALS

The Non-parametric, Mann Whitney test was done to compare the rate of tooth movement between two groups, Group A (Piezocision) and Group B (Corticotomy).

Comparison of actual tooth movement in both experimental groups at various intervals:

Based on the measurements on the study models, the mean values, standard deviations for tooth movement in group A at different time intervals were 1.33mm± 0.6 between M0-M1 (first month), 1.38mm ±0.32 between M1-M2 (second month) and 1.14mm± 0.1 between M2-M3 (third month) and in group B at different time intervals were 1.45mm± 0.51 between M0-M1, 1.54mm± 0.48 between M1-M2 and 1.27mm± 0.26 between M2-M3 **[Table 1, Graph 1].**

Comparison of rate of tooth movement in both the experimental groups at various intervals:

Based on the derived values with descriptive statistics, the mean values, standard deviations for the rate of tooth movement at various time intervals were 20.25±9.49 between M0-M1 (first month), 21.25±4.89 between M1-M2 (second month) and 17.54±2.68 between M2-M3 (third month) and in group B at various time intervals were 22.02±5.70 between M0-M1, 23.44±7.42 between M1-M2 and 19.34± 3.85 between M2-M3 **[Table 2, Graph 2].**

Average rate of space closure 59.0 ± 16.1 for 3 months, with p-value of 0.38 was achieved in the Group A and 64.8 ± 16.5, with p-value of 0.38 in Group B. And there was no statistical significance between the two groups. Comparing the rate of individual canine retraction for various time periods, Group B showed an increase in rate of tooth movement compared to Group A at the same time period **[Table 2, Graph 2].**

COMPARISON OF ACTUAL AND DERIVED TOOTH MOVEMENT BETWEEN TWO SIDES AT DIFFERENT TIME PERIODS

The Non-parametric, Mann Whitney test was done to compare the rate of tooth movement between two sides of treatment, right and left irrespective of the type of intervention.

Comparison of actual tooth movement between two sides at various intervals:

Based on the measurements on the study models , the mean values , standard deviations for tooth movement on the right side at different time intervals were 1.48mm ± 0.4 between M0-M1(first month) , 1.43mm ±0.23 between M1-M2 (second month) and 1.21mm ± 0.23 between M2-M3(third month) and on left side at different time intervals were 1.29mm ± 0.61 between M0-M1,1.49mm ± 0.43 between M1-M2 and 1.20mm ± 0.24 between M2-M3 **[Table 3 , Graph 3].**

Comparison of rate of tooth movement between two sides at various intervals:

Based on the derived values with descriptive statistics, the mean values, standard deviations for the rate of tooth movement on the right side at various time intervals were 22.53±5.78 between M0-M1 (first month), 21.79±6.3 between M1-M2 (second month) and 18.47±3.42 between M2-M3 (third month) and on the left side at various time intervals were 19.74±9.30 between M0-M1, 22.90±6.4 between M1-M2 and 18.41± 3.48 between M2-M3 **[TABLE 4, GRAPH 4].**

Average rate of space closure 62.80±14.7 for 3 months, with p-value of 0.87 was achieved on the right side and 61.06±18.27, with p-value of 0.87 on the left side. And there was no statistical significance between the two sides, right and left. Comparing the rate of individual canine retraction for various time periods right side showed an increase in rate of tooth movement compared to left side at the same time period **[Table 4, Graph 4].**

COMPARISON OF ACTUAL AND DERIVED TOOTH MOVEMENT BETWEEN HIGH ANGLE, AVERAGE ANGLE AND LOW ANGLE SUBJECTS AT VARIOUS INTERVALS

The Non-parametric, Kruskal Wallis test was done to compare the rate of tooth movement between the high angle, average angle and low angle subjects.

Comparison of actual tooth movement between high angle, average angle and low angle subjects at various intervals:

Based on the measurements on the study models , the mean values , standard deviations for tooth movement in high angle subjects at different time intervals were 1.65mm ± 0.03 between M0-M1(first month) , 1.65mm ± 0.20 between M1-M2 (second month) and 1.31mm ± 0.27 between M2-M3(third month), tooth movement in average angle subjects at different time intervals were 0.92mm ± 0.54 between M0-M1 , 1.11mm ± 0.42 between M1-M2 and 1.02mm ± 0.20 between M2-M3 and tooth movement in low angle subjects at different time intervals were 1.67mm ± 0.22 between M0-M1, 1.67mm ± 0.25 between M1-M2 and 1.32mm ± 0.15 between M2-M3 **[Table 5, Graph 5].**

Comparison of rate of tooth movement between high angle, average angle and low angle subjects at various intervals:

Based on the derived values with descriptive statistics, the mean values, standard deviations for the rate of tooth movement in high angle subjects at various time intervals were 26.32±1.21 between M0-M1(first month), 26.27±2.61 between M1-M2 (second month) and 20.85±3.86 between M2-M3 (third month)), rate of tooth movement in average angle subjects at different time intervals were 13.99 ± 7.73 between M0-M1, 17.22 ± 6.41 between M1-M2 and 15.67 ± 2.84 between M2-M3 and rate of tooth movement in low angle subjects at different time intervals were 25.20 ± 3.37

between M0-M1, 25.21 ± 3.89 between M1-M2 and 19.92 ± 2.28 between M2-M3 **[Table 6 , Graph 6].**

Average rate of space closure 73.46 ± 5.26 for 3 months, with p-value of 0.011 was achieved in the high angle subjects, 46.89 ± 15.25, with p-value of 0.011 in the average angle subjects and 70.33±8.45, with p-value of 0.011 in the low angle subjects there was statistical significance between the high angle, low angle and average angle subjects **[Table 6, Graph 6].**

ANCHOR LOSS

Type of intervention:

Molar anchor loss of approximately 0.72mm ±0.70, with p-value of 0.50 occurred during individual canine retraction in Group A within the assessed time period. Molar anchor loss of approximately 0.43mm±0.49, with p-value of 0.50 occurred during individual canine retraction in Group B within the assessed time period **[Table 7, Graph 7].**

Between right and left side:

Molar anchor loss of approximately 0.75mm ±0.70, with p-value of 0.32 occurred during individual canine retraction on the right side within the assessed time period. Molar anchor loss of approximately 0.41mm±0.46, with p-value of 0.32 occurred during individual canine retraction on the left side within the assessed time period **[Table 8].**

Between high angle, average angle and low angle subjects:

Molar anchor loss of approximately 0.00mm ±0.00, with p-value of 0.30 occurred during individual canine retraction in the high angle subjects within the assessed time period, molar anchor loss of approximately 0.58mm±0.49, with p-value of 0.30 occurred during individual canine retraction in the average angle subjects within the assessed time period and molar anchor loss of approximately .72mm ±0.70, with p-value of 0.30 occurred during individual canine retraction in the low angle subjects within the assessed time period **[Table 9].**

Comparison of anchor loss:

Statistically no significant difference was present in the anchor loss between the primary and outcome variables **[Table 7, 8, 9].**

COMPARISON OF INTERCANINE AND INTERMOLAR WIDTH BETWEEN PRE TREATMENT AND POST CANINE RETRACTION

Intercanine width:

Based on the measurements made on the 3-Dimensional scanned study models, the Intercanine width at the canine cusp tips (CT) during pre-treatment was 38.25±1.28 and at the canine cusp tips during post treatment was 40.62±1.3. The difference between pre and post treatment at the cusp tips was 2.3±0.91 with a p value of 0.00* which was statistically significant **[Table 10, Graph 8].**

Intermolar width:

Based on the measurements made on the 3Dimensional scanned study models, the Intermolar width during pretreatment at the mesiobuccal cusp tips during pre-treatment was 53.5±1.5 and during post treatment was 53±1.7. The difference between Pre and Post treatment at the mesiobuccal cusp tips was -0.50±0.75 with a p value of 0.1 which was not statistically significant **[Table 11, Graph 9].**

CANINE ANGULATION

Comparison of canine angulation between the two experimental groups:

Based on the measurements made on the pretreatment and post treatment OPG of the subjects, the mean values, standard deviations for canine angulation in group A was 91.8± 4.3 degrees in pretreatment and 84.06±5.3 degrees in post treatment with a mean difference of 7.75±4.2 degrees and the canine angulation in group B was 93.53± 2.40 degrees in pretreatment and 87.68±3.7 degrees in post treatment with a mean difference of 5.85 ±3.3 degrees **[Table 12, Graph10].**

Average canine angulation during post treatment was 84.06±5.3 in Group A and was 87.68±3.7 in Group B with a p-Value of 0.05* which was statistically significant i.e. on comparing the angulation, Group A showed an increase in the amount of canine tipping when compared to Group B. There was no statistical significance between the mean difference between pre and post retraction **[Table 12, Graph 10].**

CANINE ROTATION

Comparison of canine rotation between the two experimental groups:

Based on the measurements made on the 3Dimensional scanned study models the mean values, standard deviations for canine rotation in Group A was 32.75± 5.36 degrees in pretreatment and 23.87±3.83 degrees in post treatment with a mean difference of 8.87±5.48 degrees and the canine rotation in group B was 32.5±8.17 degrees in pretreatment and 25±5.6 degrees in post treatment and with a mean difference of 7.5 ±5.45 degrees **[Table 13, Graph 11].**

Average canine rotation during post treatment was 23.87±3.83 in Group A and was 25±5.6 in Group B with a p-Value of 0.4 which was not statistically significant but on comparing the degrees of rotation Group A showed an increase in the amount of rotation when compared to Group B. There was no statistical significance between the mean difference between pre and post retraction between both the groups **[Table 13, Graph 11].**

Tables and Graphs

Table 1: Comparison of tooth movement between two experimental groups at different time periods (in mm)

Tooth movement in time periods	Group A		Group B		p-value
	Mean±SD	Median	Mean±SD	Median	
M0-M1	1.33± 0.6	1.59	1.45± 0.51	1.52	0.95
M1-M2	1.38 ±0.32	1.4	1.54± 0.48	1.61	0.3
M2-M3	1.14± 0.1	1.16	1.27± 0.26	1.34	0.19

Table 2: Comparison of rate of tooth movement between two experimental groups at different time periods (in %)

Tooth movement in time periods	Group A		Group B		p-value
	Mean±SD (%)	Median	Mean±SD	Median	
M0-M1	20.25± 9.4	24.2790	22.02± 5.7	22.9426	0.95
M1-M2	21.25± 4.8	21.9022	23.44± 7.42	25.2490	0.38
M2-M3	17.54±2.69	17.3110	19.34±3.85	18.9908	0.32
M0-M3	59.0± 16.1	65.07%	64.8± 16.5	66.5	0.38

Table 3: Comparison of tooth movement between two sides at different time periods (in mm)

Tooth movement in time periods	Right		Left		p-value
	Mean±SD	Median	Mean±SD	Median	
M0-M1	1.48± 0.40	1.59	1.29± 0.41	1.48	0.50
M1-M2	1.43 ±0.41	1.46	1.49± 0.61	1.51	0.72
M2-M3	1.21± 0.23	1.24	1.20± 0.24	1.20	0.79

Table 4: Comparison of rate of tooth movement between two sides at different time periods (in %)

Tooth movement in time periods	Right		Left		p-value
	Mean±SD (%)	Median	Mean±SD	Median	
M0-M1	22.53± 5.78	24.25	19.74± 9.3	22.50	0.79
M1-M2	21.79± 6.3	22.87	22.90± 6.43	23.05	0.95
M2-M3	18.47±3.42	18.33	18.41±3.48	18.18	0.87
M0-M3	62.80± 14.7	65.09	61.06± 18.27	65.25	0.87

Table 5: Comparison of actual tooth movement between high angle, average angle and low angle subjects at various intervals (in mm)

Tooth movement in time periods	High angle		Average angle		Low angle		p-value
	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	
M0-M1	1.65± 0.03	1.65	0.92± 0.54	0.91	1.67± 0.22	1.64	0.025
M1-M2	1.65±0.20	1.65	1.11± 0.42	1.25	1.67±0.25	1.67	0.044
M2-M3	1.31± 0.27	1.31	1.02± 0.20	1.01	1.32± 0.15	1.33	0.056

Table 6: Comparision of rate of tooth movement between high angle, average angle and low angle subjects at different time periods (in %)

Tooth movement in time periods	High angle		Average angle		Low angle		p-value
	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	
M0-M1	26.32±1.21	26.32	13.99±7.73	14.62	25.20±3.37	25.68	0.013
M1-M2	26.27±2.61	26.27	17.22± 6.41	20.15	25.21±3.89	25.72	0.038
M2-M3	20.85±3.86	20.85	15.67±2.84	17.06	19.92±2.28	19.93	0.019
M0-M3	73.46± 5.26	73.46	46.89±15.25	50.11	70.33±8.45	70.43	0.011

Table 7: Anchor loss for the type of intervention (in mm)

Group A		Group B		p-value
Mean±SD	Median	Mean±SD	Median	
0.72± 0.70	0.90	0.43± 0.49	0.25	0.50

Table 8: Anchor loss between right and left side (in mm)

Right		Left		p-value
Mean±SD	Median	Mean±SD	Median	
0.75± 0.70	1.00	0.41± 0.46	0.25	0.32

Table 9: Anchor loss between high angle, average angle and low angle subjects (in mm)

High		Average		Low		p-value
Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	
0.0± 0.0	0	0.58± 0.49	0.75	0.72± 0.70	0.90	0.30

Table 10: Comparison of Intercanine width between pretreatment and post canine retraction (in mm)

	Pre Mean±SD	Post Mean±SD	Difference Mean±SD	p-value
At the cusp tips	38.25±1.28	40.62±1.3	2.3±0.91	0.00*

Note: * Indicates statistically significant ($p < 0.05$)

Table 11: Comparison of Intercanine width between pretreatment and post canine retraction (in mm)

	Pre Mean±SD	Post Mean±SD	Difference Mean±SD	P-value
AT THE CT	34.7±1.8	53±1.7	-0.50±0.75	0.1

Table 12: Canine angulation during pre and post treatment comparison of canine angulation between two experimental groups (in degrees)

	Pre Mean±SD	Post Mean±SD	Difference Mean±SD
Group A	91.81±4.3	84.06±5.3	7.75±4.12
Group B	93.5 ±2.4	87.68±3.7	5.8±3.3
p-value	0.5	0.05*	0.3

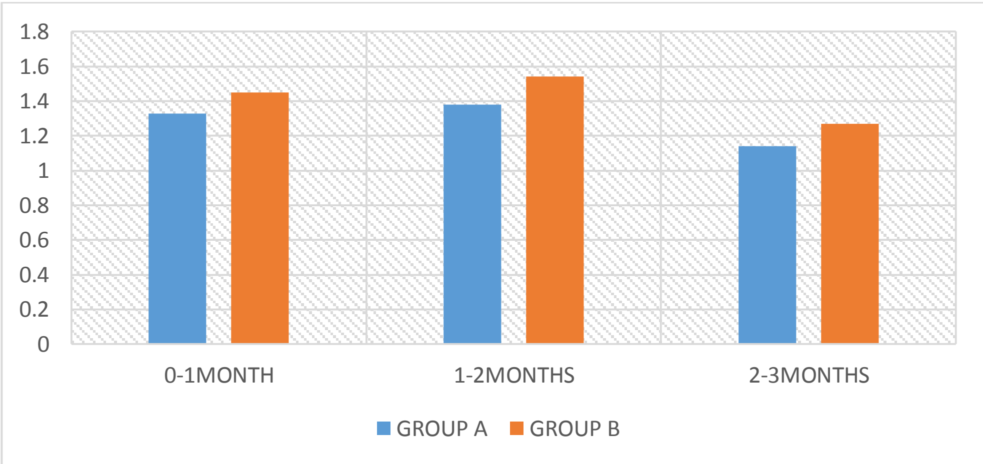
Note: * Indicates statistically significant ($p < 0.05$)

Table 13: Canine rotation during pre and post treatment comparison of canine angulation between two experimental groups (in degrees)

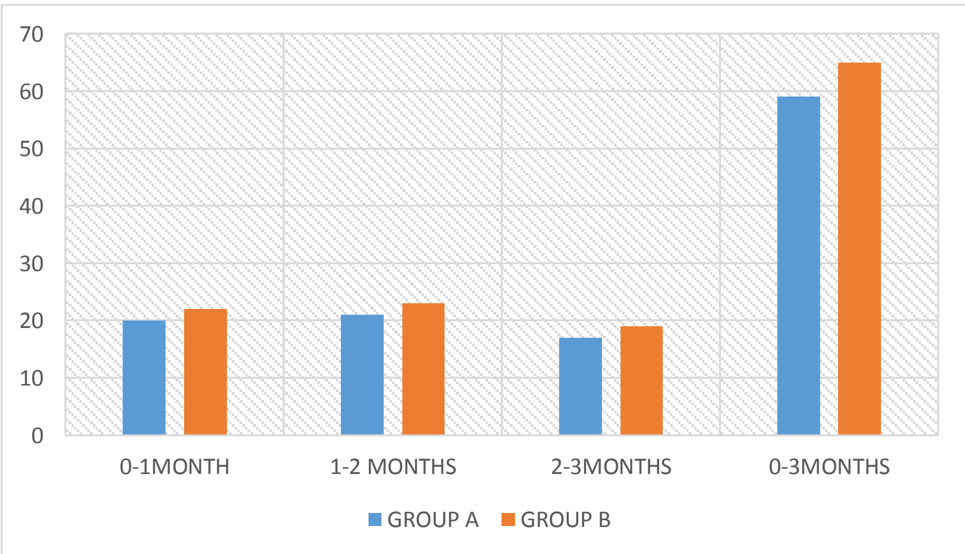
	Pre Mean±SD	**Post Mean±SD**	**Difference Mean±SD**
Group A	32.75± 5.36	23.87±3.83	8.87±5.48
Group B	32.5±8.17	25±5.6	7.5 ±5.45
p-value	0.9	0.4	0.9

TYPE OF INTERVENTION

Graph 1: Rate of tooth movement (in mm)

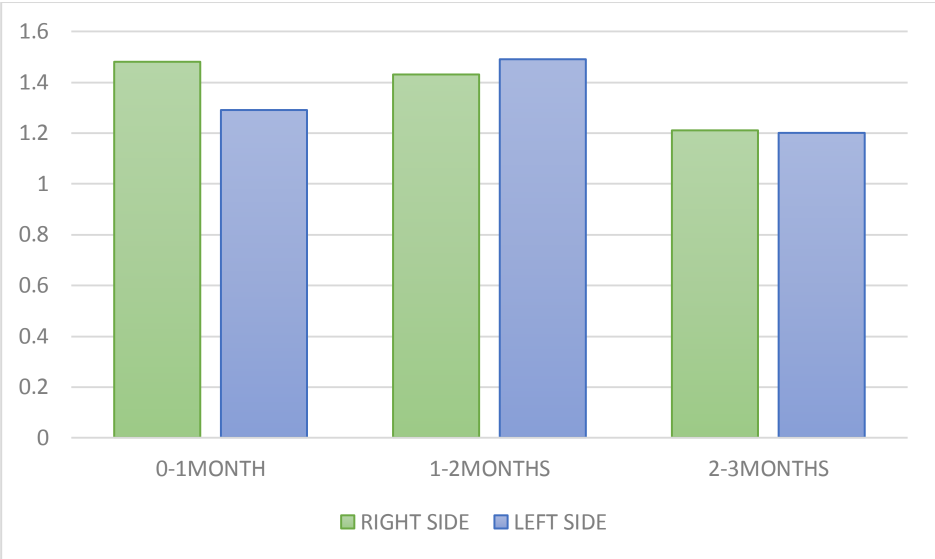


Graph 2: Rate of tooth movement (in %)

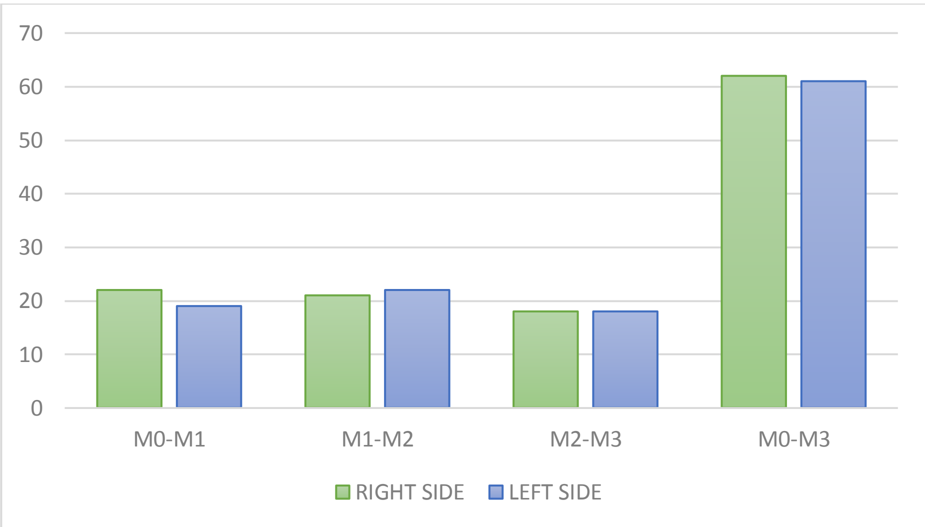


SIDE OF INTERVENTION

Graph 3: Rate of tooth movement (in mm)

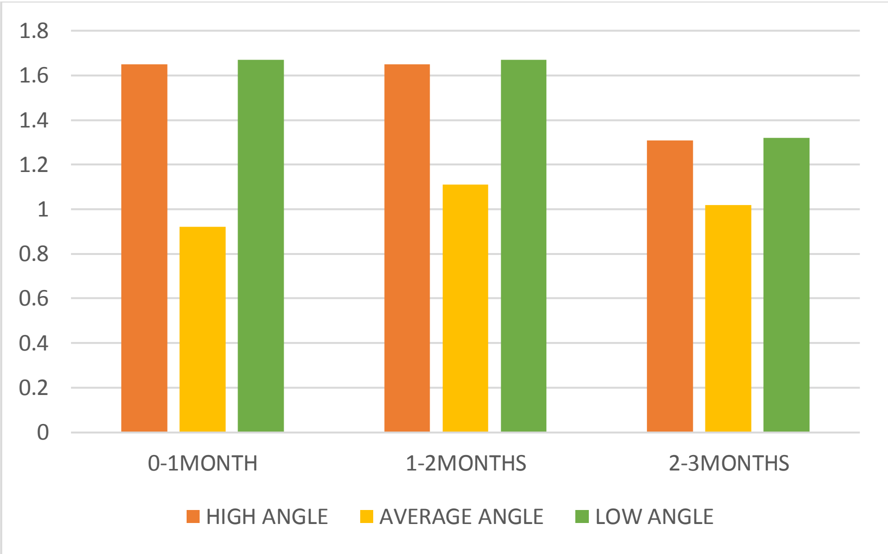


Graph 4: Rate of tooth movement (in %)

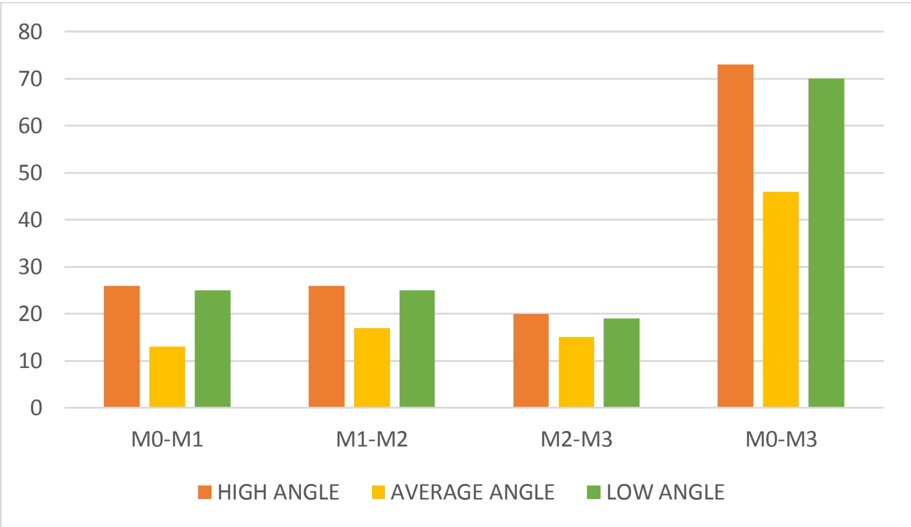


BETWEEN HIGH, AVERAGE AND LOW ANGLE SUBJECTS

Graph 5: Rate of tooth movement (in mm)

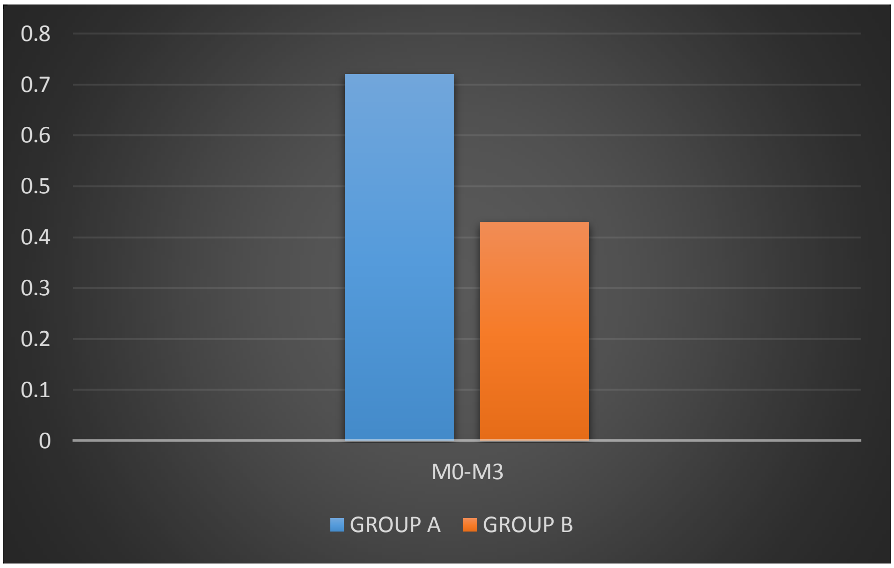


Graph 6: Rate of tooth movement (in %)



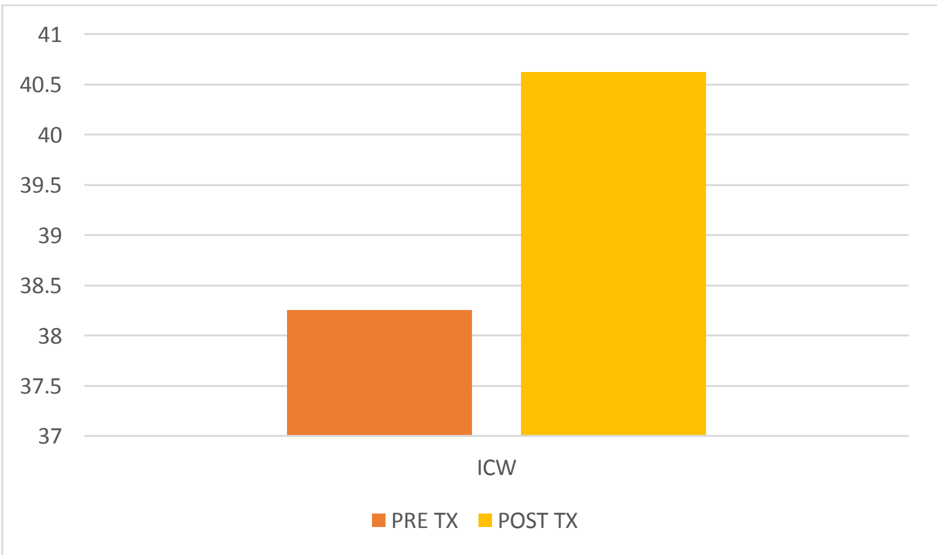
ANCHOR LOSS

Graph 7: Anchor loss between two experimental groups (3months) (in mm)



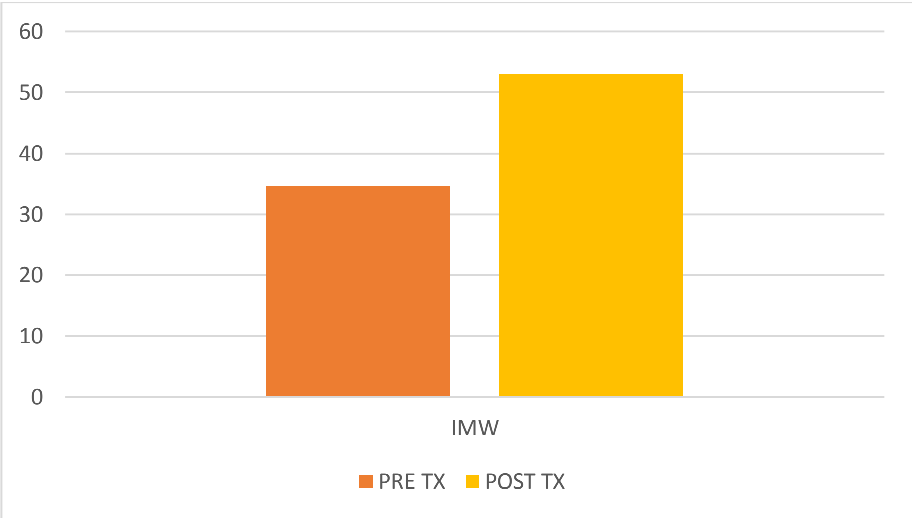
INTERCANINE WIDTH

Graph 8: Pre and Post Intercanine width (in mm)



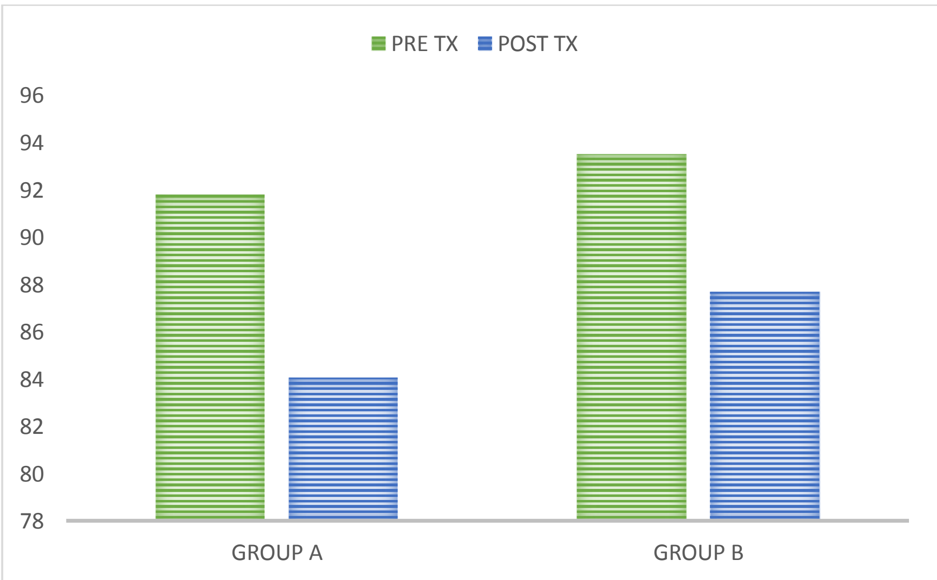
INTERMOLAR WIDTH

Graph 9: Pre and Post Intermolar width (in mm)



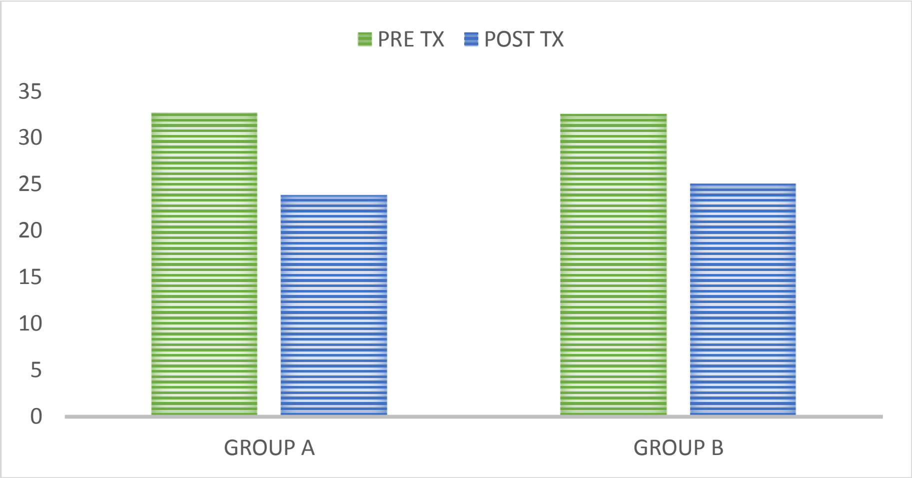
CANINE ANGULATION

Graph 10: Pre and Post Canine angulation between two experimental groups (in degrees)



CANINE ROTATION

Graph 11: Pre and Post Canine rotation between two experimental groups (in degrees)



Representative Case

PRE – TREATMENT EXTRA ORAL PHOTOS

PRE – TREATMENT INTRA ORAL PHOTOS

PRE – TREATMENT INTRA ORAL PHOTOS

PRE – TREATMENT- LATERAL CEPHALOGRAM

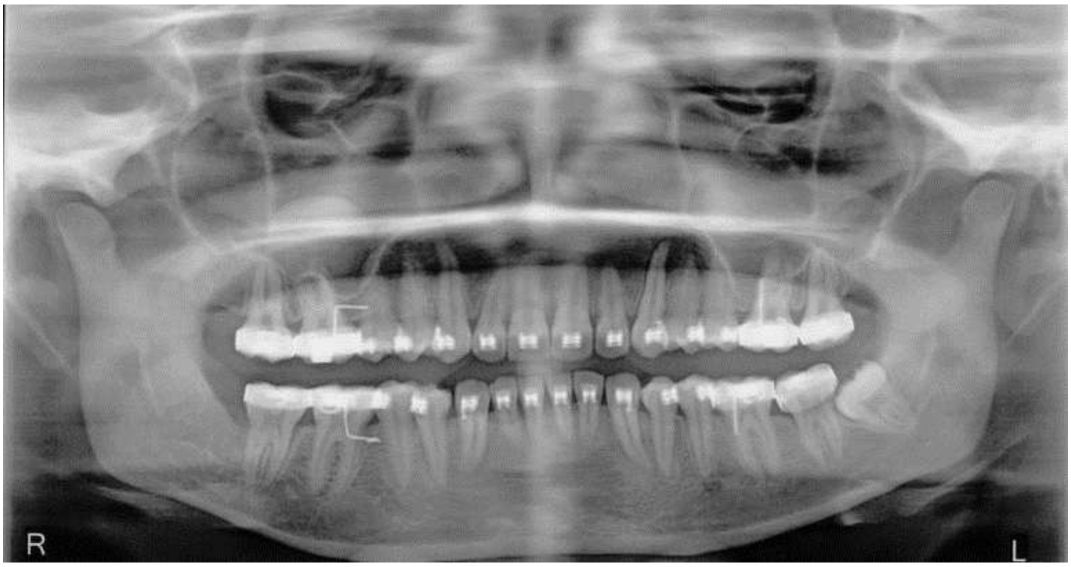
PRE – TREATMENT - ORTHOPANTOMOGRAM

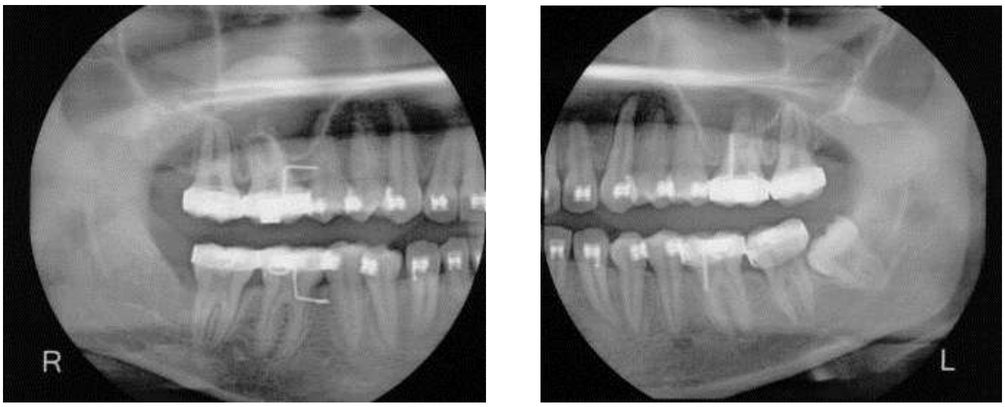
AFTER ALIGNMENT- INTRA ORAL PHOTOS

AFTER ALIGNMENT- INTRA ORAL PHOTOS

AFTER ALIGNMENT- LATERAL CEPHALOGRAM WITH JIGS

AFTER ALIGNMENT – ORTHOPANTOMOGRAM

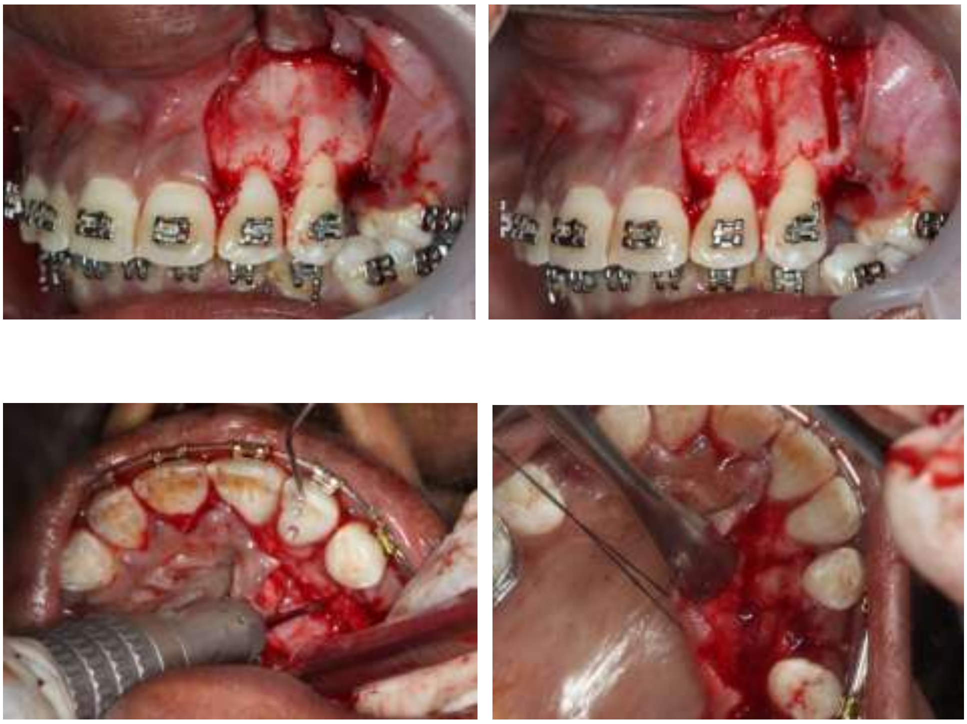




AFTER EXTRACTION – ON THE DAY OF THE INTERVENTION

PIEZOCISION – ON THE RIGHT SIDE

CORTICOTOMY (BUCCAL AND PALATAL SIDE) ON THE LEFT SIDE



SUTURING

INTRAORAL PHOTOS AT VARIOUS TIME INTERVALS

START OF RETRACTION
(M0)

END OF RETRACTION
(M3) - 3 MONTHS

(M0-M1)

(M1-M2)

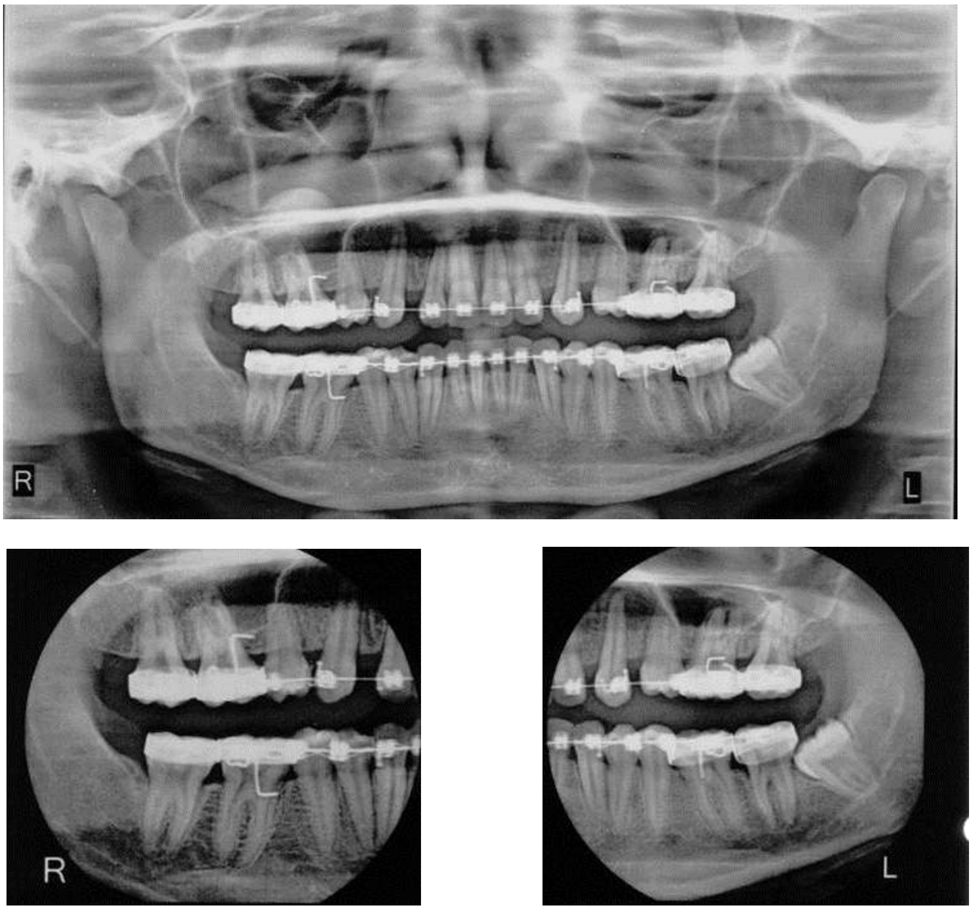
(M2-M3)

POST RETRACTION INTRAORAL PHOTOS

POST RETRACTION INTRAORAL PHOTOS

POST RETRACTION – LATERAL CEPHALOGRAM

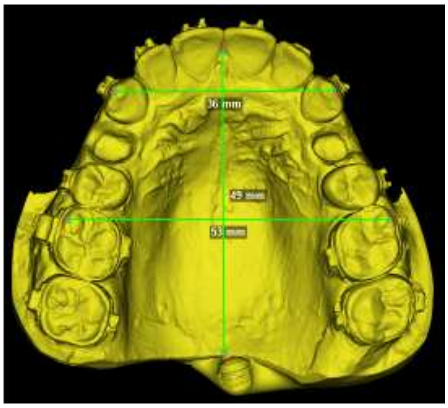
POST RETRACTION – ORTHOPANTOMOGRAM

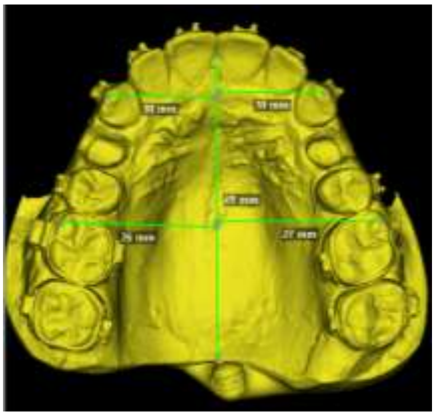


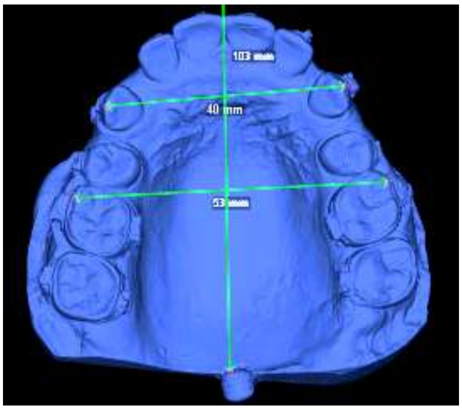
3 D STUDY MODEL WITH MEASUREMENTS

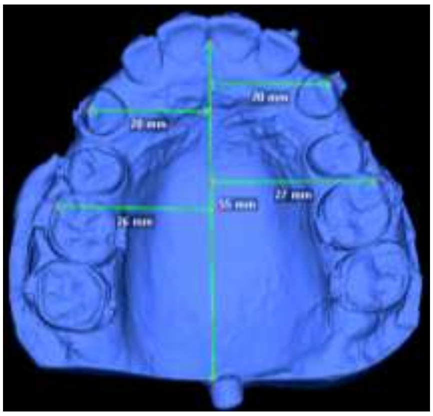
INTERCANINE AND INTERMOLAR WIDTH

(RIGHT-PIEZOCISION , LEFT – CORTICOTOMY)





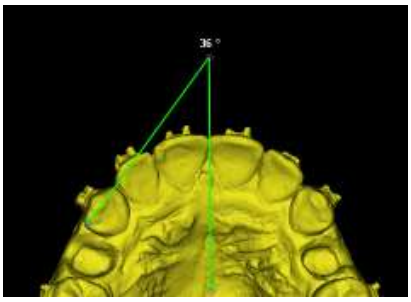


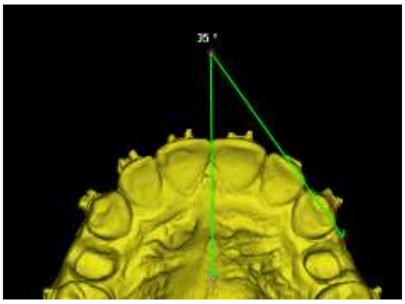


CANINE ROTATION

BEFORE RETRACTION

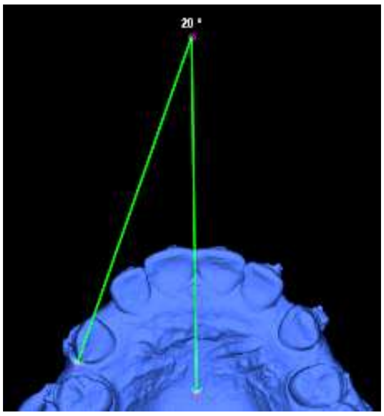
PIEZOCISION **CORTICOTOMY**

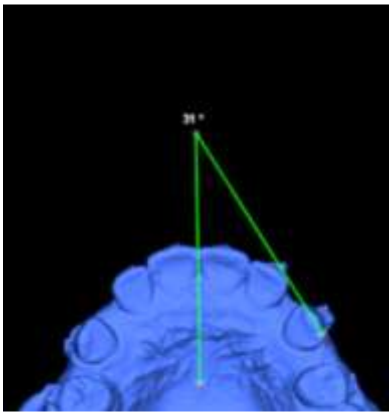




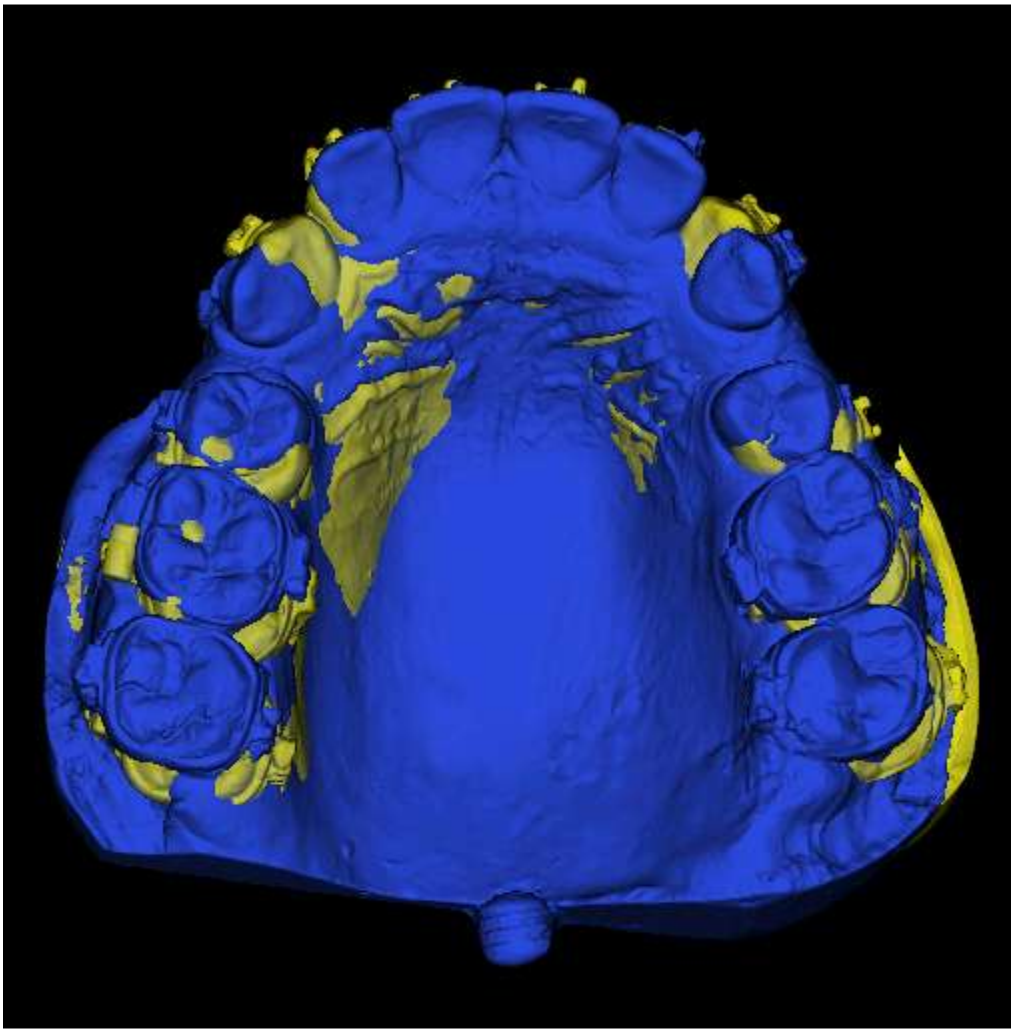
AFTER 3 MONTHS OF RETRACTION

PIEZOCISION **CORTICOTOMY**





3DIMENSIONAL SUPERIMPOSITION

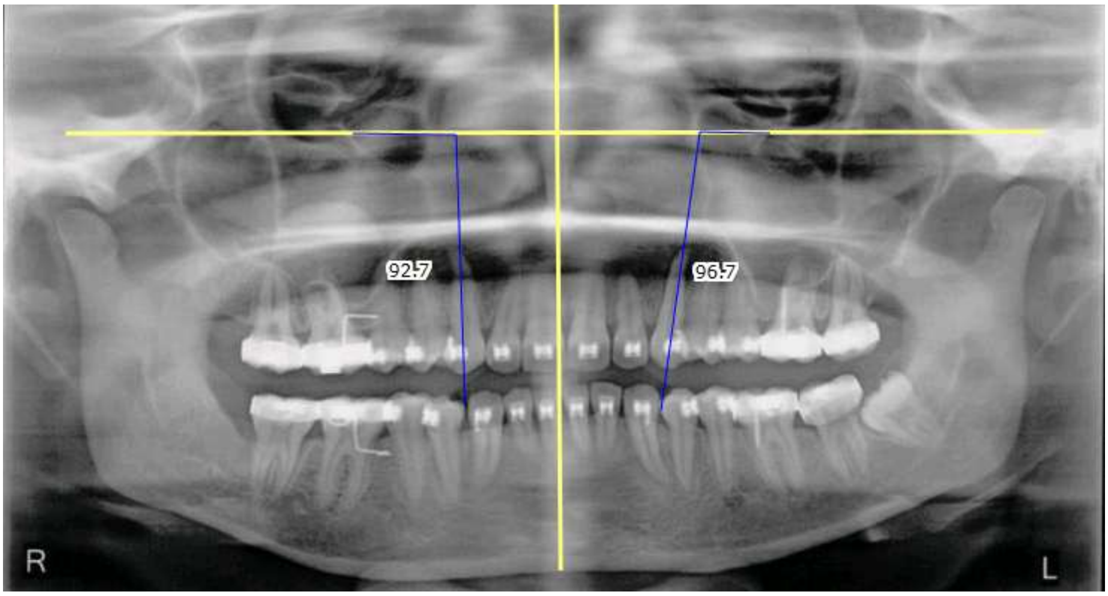


– PRE TREATMENT

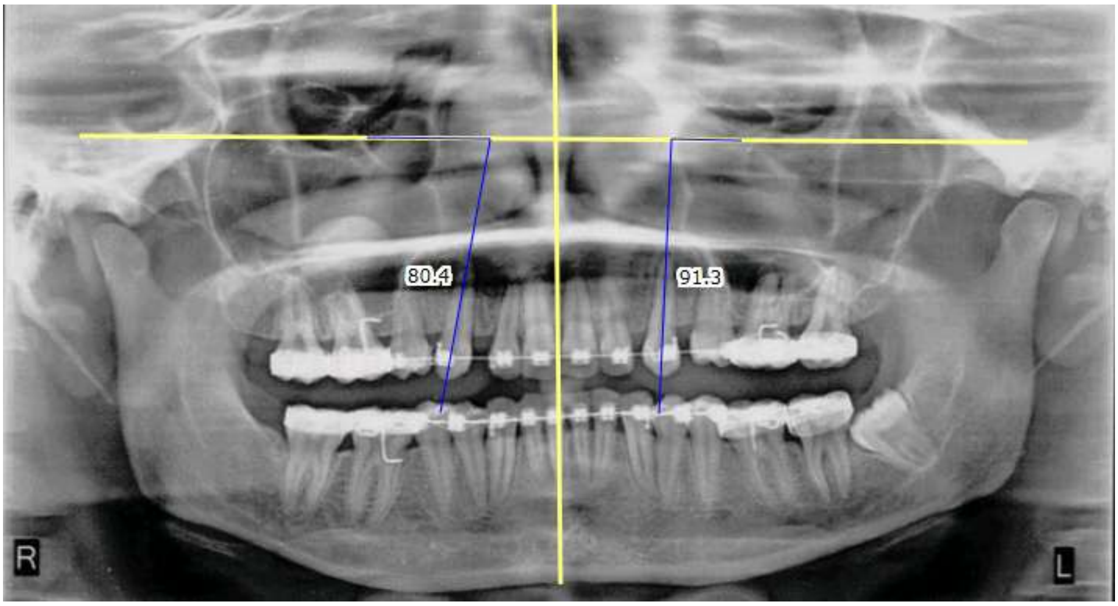
– POST TREATMENT

ORTHOPANTOMOGRAM WITH CANINE ANGULATION MEASUREMENT

PIEZOCISION **CORTICOTOMY**



PIEZOCISION **CORTICOTOMY**



Discussion

DISCUSSION

Length of treatment time is an important factor for adult patients and the main goal of orthodontic treatment is to improve the patient's quality of life by enhancing the dentofacial functions and esthetics. Reducing orthodontic treatment time is one of the primary goals for orthodontists as it will lead to increased patient satisfaction especially, adults. Aging produces biological changes in the bone composition and the cells become less reactive and metabolism slows down which results in decrease in the bone turnover and retards the rate of orthodontic tooth movement.

Lengthy treatment time may prompt patients, especially adults to either elude treatment or to seek compromised alternative options. Therefore, different modalities that would shorten the treatment time without undermining the treatment outcome are in demand. Shorter overall treatment time, leads to fewer complications, more compliant and satisfied patients. Till date, many attempts have been made to shorten the duration of treatment.[70] These techniques include rapid distraction of the canines[3] and corticotomy-facilitated orthodontics.[32]

In a systematic review by **Hoogeveen et al[29]** corticotomy and dental distraction which have been proposed as effective and safe methods to shorten orthodontic treatment duration in adolescent and adult patients. They concluded that the evidence suggested that surgically facilitated orthodontics seemed to be safe for the oral tissues and is characterized by a temporary phase of accelerated tooth movement. This can effectively shorten the duration of orthodontic treatment. But the level of evidence to support these findings is limited owing to shortcomings in research methodologies and small treated groups and further prospective clinical studies are required.

The systematic review by **Hu Long et al,**[64] on the effectiveness of interventions on accelerating orthodontic tooth movement revealed that: Low-level laser therapy was ineffective to accelerate orthodontic tooth movement, evidence is still not conclusive whether electrical current and pulsed electromagnetic fields can definitively accelerate tooth movement. Dentoalveolar or periodontal distraction is a promising method to accelerate orthodontic tooth movement but lacks convincing evidence. Whereas corticotomy is documented to be an effective and safe procedure to accelerate orthodontic tooth movement. Therefore corticotomy facilitated technique was used in the current study as documented evidences proved it to be a safe modality for intervention to accelerate orthodontic tooth movement.

Corticotomy is a surgical technique in which only the cortical bone is cut, perforated or mechanically altered up to the depth of the medullary bone and the medullary bone remains intact. Corticotomy (selective alveolar decortication) can be efficaciously used to correct dento-alveolar and moderate alveolo-skeletal problems. When the severity increases from alveolo-skeletal to pure skeletal problems, osteotomy and/or distraction osteogenesis would be the choice of treatment.

Decortication produces a catabolic process, a resorption response, characterized by osteopenia causing reduction in bone density, with no change in alveolar bone volume.[33] The remaining collagenous soft tissue matrix of the bone is transported with the root in the direction of movement termed, “bone matrix transportation”.[108] The osteoid matrix gets subsequently re-mineralized by the anabolic process.

Corticotomy or decortication simply refers to the intentional severing of the cortical bone. The technique has been claimed to dramatically reduce the treatment time because the resistance of the dense cortical bone to orthodontic tooth movement is eliminated.[15,36,37,54,99] This decreased resistance has been explained by the underlying regional acceleratory phenomenon (RAP) that occurs after a wound; RAP involves the recruitment of osteoclasts and osteoblasts to the injured site for wound healing, which leads to a transient localized demineralization-remineralization phenomenon in the bony alveolar housing.[112]

Chung et al in their study, claimed that corticotomy when combined with heavy forces lead to histologic changes called the Compression osteogenesis where the medullary bone was more plastic and malleable (temporary osteopenia). They produced effective acceleratory orthodontic rotation and tipping movement. The high medullary bone turnover in healthy tissues results in new bone formation with low bone density the key which provides more rapid tooth movement. Thus the nature of tooth movement in corticotomy assisted retraction is Dentoalveolar, with tipping followed by up righting.[16]

It has been stated that corticotomy facilitated orthodontics decreases the undesirable adverse effects of orthodontic treatment including root resorption and periodontal damage. The main drawback of corticotomy is its minimal acceptance by patients because of the aggressiveness of these procedures, which increase postoperative discomfort and the risk of complications.[36]

Minor drawbacks of corticotomy include slight interdental bone loss and loss of attached gingiva,[58] to periodontal defects observed in some cases, with short interdental distance.[28] The various complications like subcutaneous hematomas of the face and the neck have been reported after intensive corticotomies, while postoperative swelling and pain lasts for several days. However, no effect on the vitality of the pulpal tissue of teeth, in the area of the corticotomy, has been reported.[77,62,45]

There is concrete evidence in the literature as given by **William M. Wilcko et al,**[109] **Raffaele spena et al,**[96] **Fischer et al,**[34] **Dauro Duglas Oliveira et al,**[21] **Mostafa et al,**[72] **Generson** and **Porter et al,**[37] **Chung et al,**[15] **Ali H Hassan et al** [2], **Hyo-Won Ahn et al,**[48] **Shoichiro Lino et al** [61] and many others suggesting that corticotomy is a viable option for accelerating orthodontic treatment.

Corticotomy has been proved to be the gold standard procedure in terms of accelerating tooth movement but the drawback of this technique being moderately invasive, several minimally invasive procedures have been introduced to accelerate the orthodontic tooth movement by minimizing patient discomfort and morbidity. The main aim of this study was to compare corticotomy to one of the minimally invasive procedures which is in vogue in recent times.

Park and Kim et al, introduced the corticision technique as a minimally invasive alternative to create surgical injury to the bone without flap reflection. This technique used scalpel and a mallet to go through the gingiva and cortical bone without raising a flap. Drawbacks of this technique is the inability to graft soft or hard tissues, repeated malleting causes dizziness after surgery. This technique has no fixed protocol and the forces generated maybe high and deleterious.[78]

E.Khoo et al, discussed that researchers from the Consortium for Translational Orthodontic Research (CTOR) at New York University College of Dentistry have been able to develop a technique to increase the rate of tooth movement, applying the same biological principles activated during bone remodeling. Taking advantage of this bone repair mechanism, NYU researchers developed a method called Alveocentesis to accelerate tooth movement. Micro-osteoperforations are created in the alveolar bone adjacent to the teeth that need to be moved, under local anesthesia, without the need to raise any flap.[52] This method moves teeth at least twice as fast as the normal rate shown in both animal and human studies. As seen in these case series, the use of conservative osteoperforations may prove to be a useful technique for accelerating tooth movement. **Mani Alikhani et al** in their study, opined that MOPs are safe and a minimally invasive procedure to accelerate orthodontic tooth movement but the effectiveness of the procedure has not been evaluated.[67]

Dibart et al, developed a new minimally invasive technique known as Piezocision, which involves microincisions with selective tunneling that allows for hard and soft tissue grafting and piezoelectric incisions. The Piezocision demonstrated similar clinical outcome when compared to classic decortication approach but has the added advantages of being quick, minimally invasive, and less traumatic to the patient. This technique is quite versatile as it allows soft-tissue grafting at the time of surgery to correct mucogingival defects if needed, as well as bone grafting in selected areas by using localized tunneling.[26] Piezocision has successfully been used for the rapid treatment of Class II [25] and Class III [30] patients and has been combined with lingual orthodontics [10] and the Invisalign system [50] to achieve both esthetic and rapid treatment and Piezocision being the middle ground in accelerating tooth movement in comparison with corticotomy and Micro-Osteoperforations. We designed a split mouth study to compare the effectiveness of corticotomy and piezocision during space closure in individual canine retraction and the changes were assessed.

The sample size for the split mouth design is approximately half that of a parallel sided trial and also the individual bias/variability is eliminated in a split mouth study. We need to take into consideration whether the effect of an intervention on one side of the mouth influences the outcomes on the other side of the mouth. But in our study since both the interventions were randomized and performed on the same patient the effect of intervention on one side was not likely to influence the rate of tooth movement on the other side since the effect from each side gets negated.

To eliminate the effect of age on tooth movement, only adults with Class II Division I malocclusion who required only maxillary first premolar extraction were included in this study as it would facilitate individual canine retraction without encountering any occlusal interference from the lower dentition.

In our study**,** the ‘‘two-step’’ technique was followed i.e. the canines and incisors were retracted in two separate steps. In retracting the canines separately in the first step, the load on the posterior teeth was lowered, thus reducing the tendency of the maxillary molars to displace forward. In the second step, the posterior segments which were buttressed by the incorporation of the canine are pitted against the reduced resistance of the incisors alone.[12,40]

Proffit and Fields et al recommended separate canine retraction for maximum anchorage, stating that this approach would allow the reaction force to be constantly dissipated over the large periodontal ligament area in the anchor unit. They acknowledged, however, that closing the space in two steps rather than in one would take nearly twice as long.[79] Also **Andrew J Kuhlberg et al**, described separate canine retraction as less taxing on anchorage because the two canines were opposed by several posterior teeth in the anchor unit.[4] Thus, individual canine retraction was performed in our split mouth study.

By classical methods 0.7-0.9 mm (rate of 0.28mm per week) canine distalization per month is achieved. In extraction cases canine distalization takes an average of 4-8 months.[5] The present split mouth study was undertaken primarily to evaluate and compare the effects of corticotomy and piezocision on individual canine retraction and to assess the changes.

The use of a 0.016x0.022-in wire in a 0.022-in slot might lead to uncontrolled tipping of the canines in all sides i.e. a smaller size arch wire may lead to an increase in the play (SLOP) between the archwire and the bracket slot.[11] Hence in our study 0.017x0.025 SS was the archwire of choice since smaller size archwires would result in excessive tipping while the larger dimension archwires like 0.019x0.025 SS and 0.021x0.025 SS induce greater resistance to sliding thereby taxing anchorage.

In this study group, the leveling and aligning was carried out until 0.017x0.025 SS wire was engaged to perform individual canine retraction. The first premolars were not-extracted till the time the retraction stage in the treatment was started as it would mislead the results whether the tooth has moved due to extraction or due to the Regional Acceleratory Phenomenon procedure.[86] Maxillary arch was split between right and left sides and piezocision was performed mesial and distal to the canine root on one side and corticotomy was performed similarly on the other side and individual canine retraction was initiated using 9mm NiTi closed coil spring (GAC Sent alloy springs, USA, 150gms of force measured with Dontrix gauge) to maintain a constant force delivery and uniform range of action.

The interventions were performed on the same individual to eliminate the difference in biological response, bone turnover, cellular mechanisms and bone biology. Both the interventions were not severely invasive as it was performed only for individual canine retraction and the Ethical approval was obtained from the Institutional Review Board.

N Hussein Abbas et al evaluated the efficiency of corticotomy-facilitated orthodontics and piezocision in rapid canine retraction. A sample of 20 patients (15-25 years old) with Class II Division 1 malocclusions who underwent extraction of the maxillary first premolars with subsequent canine retraction were used. The sample was divided into 2 equal groups. In the first group, one side of the maxillary arch was treated with corticotomy, and in the second group, piezocision was performed. The contralateral sides of both groups served as the controls. The rates of canine crown tip were greater in the experimental sides than in the control sides in both groups. Corticotomies produced greater rates of canine movement than did piezocision. Canine root resorption was greater in the control sides. They concluded that Corticotomy-facilitated orthodontics and piezocision were efficient treatment modalities for accelerating canine retraction.[76]

The corticotomy procedure performed in our study is a modified protocol unlike the Wilcko's Protocol where corticotomy was performed prior to aligning and an additional procedure namely Ostectomy (surgical removal of cortical plate) in the extraction space was required which is both cumbersome and expensive to the patient because of additional grafting required in the area. The outcome is not significantly different from other studies where corticotomy was employed and no bone graft was used as the patient was not periodontally compromised, no thin alveolar bone or any other indications. In a point/counterpoint by **Dave.P.Mathews and Vincent Kokich** [22], it is stated that there is no evidence in the literature that bone grafting of the alveolus enhances the stability of the orthodontic result and in a study by **Engelking and Zachrisson**[31] showed that retraction of mandibular incisors leads to repair of dehiscences with 2.5 to 3.1 mm of new bone formed without bone grafting. Thus in our study no bone graft was used as only vertical cuts were performed mesial and distal of canine.

The corticotomy procedure in this study is performed similar to that advocated by **Fadi Al Nahoum et al**. wherein, gingival mucoperiosteal flaps were raised to expose cortical bone on both the buccal and palatal sides of the canine. The horizontal cut line of the corticotomy was made above the apices of the canine 2 to 3 mm on the buccal side and at the level of the palatal groove on the palatal side. The vertical cut lines were made 1 to 2 mm apical to the alveolar crests of the canine to the horizontal cut lines on the buccal and palatal sides. Small corticotomy perforations were drilled in the buccal and palatal cortical bone (about 20 perforations on each side. The corticotomy cuts were performed to a depth of 2 mm by a fissure bur (width 2 mm), and perforations were made using a round bur (diameter 2 mm) under saline solution irrigation.[32] Similarly in our study the surgical scarring penetrating only the cortical bone without involving the medullary bone was performed.

The procedure employed in our study has the advantage of being less invasive, was done under local anesthesia and is a simpler technique since corticotomy perforations/vertical cuts were performed only mesial and distal to the canine.

In our study 701 tapering fissure bur for interdental scoring and no.2 round bur for punch hole perforation was used which is an acceptable method for decortications.[13, 41, 72]

In our study, the other intervention was piezocision which is performed only on the labial side. The mechanism of action of piezocision is based on the biologic concept of activating cortical bone rather than removing of cortical bone. In our study a depth of 3mm cortical activation was followed to create osseous injury.

Piezoelectric micro-vibration allows for a selective cut of mineralized structures, causing no damage to soft tissues when accidentally contacted.[98] Micrometric vibration gives a precise cut and at the same time maintains a blood free site. This is due to the physical phenomenon of cavitation by irrigation, providing greater safety, especially in anatomically difficult areas. This technique reduces osteocyte damage and allows survival of bone cells.

Piezocision can be used in a generalized, localized or sequential manner.[88] Piezocision can be performed more than once in the same area to restore and to keep RAP active (after 5 or 6 months) and to keep the area demineralized but it is dependent on the morphology of the patient's bone and the tooth movement required. In our study, vertical incisions were made mesial and distal to the canine to be distalized and we evaluated RAP phenomenon for a one time surgical intervention. The insert was used perpendicular to the bone to a depth of 3-4mm, length of 5mm mesial and distal to the canine and care was taken to reduce the soft tissue contact as it can cause sequestration. The depth of the penetration was gauged with the BS1 insert, as it has laser etched marking.

The duration and rate of retraction between corticotomy and piezocision was assessed with the help of study models taken at different time intervals between 0-1 month (M0-M1), 1-2 months (M1-M2) and 2-3 months (M2-M3). The space closure was assessed between the maximum contour distal to the canine and mesial surface of the second premolar. **Ziegler and Ingervall et al** used the posterior rugae and the midpalatal raphe as reference point and line respectively[115] and **Lotzof et al**, designed an acrylic mould of the anterior palate and two wires projected to the central fossa of first molar, to assess molar anchor loss during canine retraction.[65]

In our study, the duration, rate of tooth movement and anchor loss was assessed and compared between the right and left side of the patients to check for the dominant side, effect on tooth movement and also between the high, low and average angle subjects in which subjects tooth movement was faster.

The molar anchor loss value had not been documented convincingly for such split mouth studies involving corticotomy and piezocision assisted canine retraction.[32] Therefore, our study aimed to evaluate the rate of retraction and the amount of molar anchor loss that occurred during the individual canine retraction on both sides of intervention during the given period of time. The posterior segments (second premolar, first molar and second molar) were not decorticated on both the sides since osteopenia is required only 2- 3mm around the teeth to be moved and in the posterior segment anchorage values were maintained. Temporary Anchorage Devices were not used in this study, this is to assess whether the undecorticated posterior teeth (1st molar, 2nd molar and second premolar) can act as an anchorage unit. The posterior segment was consolidated to act as a single unit.

The palatal rugae was not used to assess the anchor loss of molars, since the palatal flap was also reflected on the corticotomy side and sutured back. So it would not serve as a reliable landmark.

Anchor loss was assessed with the help of digital lateral cephalograms similar to the method proposed by **Badri Thiruvengadachari**, with modified jigs placed on the upper and lower, right and left first molars to differentiate the right side from the left side molar. Anchor loss was correlated with the space closure and effective individual canine retraction was assessed and compared between both the study groups for a period of 3 months.[100]

Sousa et al, compared digital models to conventional models to assess the accuracy of tooth material, arch width and length. The results of their study stated that the reproducibility of digital measurements of arch width and length on digital models were similar to direct measurements on the dental casts with a caliper and also the measurements of arch width, tooth material and length on digitized models showed high accuracy. Therefore 3 Dimensional models are reliable and the measurements made are accurate.

In our study, 3-Dimensional models were taken and scanned using Zikron Zhan scanner S600 series software. Pretreatment and post treatment superimposition was performed using the Dolphin Software, 11.8, USA. All the measurements of canine rotation, inter-canine and inter-molar widths were made on the 3D models using the Dolphin Software, 11.8 version.

The inter-canine and inter-molar measurements were made pre retraction and 3 months post retraction. The widths of the anterior and posterior parts of the maxillary cast i.e. the inter-canine and inter-molar measurements of the maxillary dental arch were measured at the canine and the first molar regions. The cusp tips of the teeth were chosen as the measuring landmarks instead of the labial surfaces of the teeth.

Gianelly et al used labial surfaces to determine the widest widths to prevent confusion when selected cusp tips were not distinct. These measurement points can have reasonable effects but should not be used for every study.[39] In a similar study performed by **Sukurica et al,** cusp tips were used.[98] In our study, the cusp tips were selected because of their good visibility and there were no signs of attrition and were easy to use with the 3D model analysis system from the most labial aspect of the buccal surfaces of those teeth, as described by the changes pre and post treatment were calculated on the 3D models and compared.

Bouwens et al compared the mesiodistal root angulations by using post treatment panoramic radiographic images and CBCT scans and concluded that panoramic images provide reliable information regarding mesiodistal tooth angulations and might exhibit deviations in both mesial and distal directions for all teeth but when using panoramic radiographs for assessment of mesiodistal tooth angulations throughout treatment, the radiographic data must be combined with a thorough intraoral evaluation to produce the most satisfactory results.[20] In their study the occlusal plane was used as the reference plane to assess the tooth angulation and drawback was that the occlusal plane is not a stable landmark as it is affected by the focal trough changes and during treatment hence in our study the Orbitale-Orbitale plane was used as reference which is a stable landmark and is unaffected by the focal trough and also remains constant before and after treatment. Orbitale is used as a stable reference in assessing frontal asymmetry cases according to **Grummons et al**.[42] The canine angulation before and 3 months after individual canine retraction was assessed and compared between both the study groups.

Neam F Agha et al demonstrated a new method to record linear and angular measurements to record the amount of canine rotation after orthodontic treatment.[3] A study model was taken for them pre and post treatment, then measurements were done directly on the cast and other measurements indirectly converted on a paper to measure other variables. Canine rotation occurs within the treatment time period in the two methods of measuring canine rotation, but this research proved that the linear direct measurement and angular measurements were effective in measuring the canine rotation. The corticotomy on the palatal side was done such that it was not extended till the median palatal raphae and thus can be used as a stable reference. In our study 3D models were used to measure the canine rotation by connecting the median palatal raphe and by drawing a line connecting the mesial and distal sides of the canine width forming the canine angle.

In our study, there was no significant difference in the extraction space between the right and the left side of the patients and it accounted to be, on an average of 6.58mm on the right side and 6.51mm on the left side.

59.05% (3.85mm) of extraction space closure was achieved by individual canine retraction at the end of 3rd month in Group A (Piezocision group). Whereas 64.80% (4.26mm) of extraction space closure was achieved in Group B (Corticotomy group) for the same period of time i.e. by the end of 3rd month.

The average rate of space closure was 1.33mm/month in Group A and 1.45mm/month in Group B. This correlates with the studies of **Aboul Ela et al** who calculated the mean rates of individual maxillary canine retraction with buccal corticotomy alone and a retraction force of 150 grams was on an average about 1.42mm / month[86] and **Sertac Aksakalli et al** who calculated the rate of individual canine retraction with piezocision and found it to be on an average of about 1.37mm/month.[89]

In our study, on comparing the rate of tooth movement between the two experimental groups, Group B showed faster tooth movement than Group A but it was not statistically significant. This correlates with the study of

N Hussein Abbas et al, who evaluated the efficiency of corticotomy-facilitated orthodontics and piezocision in rapid canine retraction. Corticotomies produced greater rates of canine movement than did piezocision. Canine root resorption was greater in the control side. They concluded that Corticotomy-facilitated orthodontics and piezocision were efficient treatment modalities for accelerating canine retraction.[76]

Dixon et al in a previous study, used NiTi coil spring delivering 200grams force for retraction which showed the highest rate of space closure of about 0.81mm/ month and attained 32% of extraction space closure by the 4th month. The rate of space closure per month in both the experimental groups is approximately 59% and 65% of the extraction space by the end of 3rd month in our study which may be due to more efficient protocols for individual canine retraction.[27]

Though the average rate of retraction in Group A and Group B was 1.33mm/month and 1.45mm/month respectively, there was a peak increase during the first two months of retraction in Group A and Group B (1.44mm/month and 1.61mm/month respectively) which started to reduce by the end of 3-4 months. This finding concurs with that of **Aboul Ela et al** who reported that the rate of space closure peaked during the end of 1st and 2nd month and reduced by the end of 4th month.[86] This could be biologically co-related with the transient RAP phenomenon as published by **Frost** which remains active for 4 months. Thus the time period assessment of retraction for the first 3-4 months period after accelerated orthodontic procedures can be substantiated.

An average anchor loss of 0.72mm occurred in Group A and 0.43mm in Group B during the study period of 3 months. There was no statistically significant difference between both the experimental groups in molar anchorage loss. The un-decorticated posterior segment can effectively act as an anchorage module. Thus both the procedures are effective in controlling anchorage loss. There was no anchorage loss during the first two months even though the RAP was higher in the first two months there was no taxation of anchorage and the anchor loss was found to gradually increase only by the end of 2-3rd month of retraction, although not statistically significant. The finding of our study correlates with the study by **Sakthi et al**, [83] where the average anchor loss of 0.39mm occurred in the maxilla and in the mandible for a maximum of 4 to 6 months. There was better anchorage control with the un-decorticated molar segment during the retraction period but the amount of anchor loss was found to increase as time period advanced.

In our study, the duration, rate of tooth movement and anchor loss were not statistically significant between the right and left side of the patients and the duration and rate of tooth movement was faster in the high angle subjects followed by low angle subjects and then average angle subjects. Several studies stated that the muscular forces and the bite forces are statistically significant in the average angle subjects than the low angle subjects but owing to the less sample size in our study we cannot conclusively state that rate of tooth movement is faster in a certain growth pattern.

In our study, the inter-canine width measured at the cusp tips of canine before retraction was 38.25mm and 3 months after individual canine retraction was 40.62mm which was statistically significant in both the experimental groups. Whereas the inter-molar width measured at the mesiobuccal cusp tips before retraction was 53.5mm and 3 months after individual canine retraction was 53mm which was not statistically significant. The finding of our study correlates with **Muge Aksu et al,**[73] who in their study examined the dental arch width changes of extraction and non-extraction treatment in Class I patients. The study was performed on pretreatment and post treatment dental casts of 60 patients and at the end of treatment, maxillary and mandibular inter-canine widths of both groups increased significantly. The mandibular inter-molar width decreased significantly for the extraction group and the maxillary inter-molar width increased significantly for the non-extraction group. The decrease in maxillary inter-molar width for the extraction group and the increase in mandibular inter-molar width for the non-extraction group were not significantly different.

In our study, the canine angulation was measured at pretreatment (M0) and 3 months (M3) after retraction and was compared between the two experimental groups. In Group A, the canine angulation was 91.81 degrees before retraction and was 84.06 degrees 3 months post retraction and in Group

B, the canine angulation was 93.53 degrees before retraction and 87.68 degrees 3 months post retraction i.e. during and post retraction there was evident canine tipping in both the experimental groups. Group A showed an increased canine tipping when compared to Group B which was statistically significant. The findings of our study correlates with **N Hussein Abbas et al** [76] who evaluated the efficiency of corticotomy-facilitated orthodontics and piezocision in rapid canine retraction. The rates of canine crown tip were greater in the experimental sides than in the control sides in both groups.

In our study, the canine rotation was measured before and 3 months after retraction and was compared between the two experimental groups. In Group A, the canine rotation was 32.75± 5.36 degrees before retraction and was 23.87±3.83 degrees 3 months post retraction and in Group B, the canine rotation was 32.5±8.17 degrees before retraction and 25±5.6 degrees 3 months post retraction. There was evidence of canine rotation during and post retraction in both the experimental groups. Group A showed an increased canine rotation when compared to Group B which was not statistically significant.

Though corticotomy assisted orthodontic treatment (CAOT) has beneficial outcome in terms of duration of treatment, its limitations in cases of active periodontal disease or gingival recession should be a consideration. In contrast to the findings of **Lindhe et al**,[60] **Bell and Levy et al** [6] and **Yaffe et al** [112] who reported slight interdental bone losses, decrease in the attached gingiva, and periodontal defects, in our study there was no significant adverse effects on the periodontium after corticotomy. Our observations agree with those of **Gantes et al**, [36] **Wilcko et al** [110] and **Lino et al**. [61]

The average rate of canine retraction on the piezocision side was 1.5 to 2 times higher than the conventional rate of canine retraction and on the corticotomy side was 2 times higher than the conventional canine retraction.[76]

The piezocision technique in our study, resulted in clinical outcomes that were similar to those of the classic decortication approach, but piezocision had the added advantages of being minimally invasive, precise, and less traumatic for the patient. However, this technique was time-consuming because of the decreased cutting efficiency of the Piezotome blades relative to conventional burs. Both the procedures are effective but due to limited sample size the effectiveness could not be assessed with various predictor and outcome variables. Further studies should be done with adequate sample size to confirm the outcome.

Summary and Conclusion

SUMMARY AND CONCLUSION

The present clinical study was performed to evaluate and compare the effectiveness of piezocision and corticotomy during individual canine retraction in a split mouth study.

The following conclusions were drawn from the present study:

1. The rate of retraction accelerated during the first two months of retraction and gradually decreased at the end of the study period (3 months) in both the experimental groups. The rate of tooth movement was increased in the corticotomy group when compared to the piezocision group with no significant difference.
2. There was no significant differences in the rate of tooth movement between right and left sides in both the arches.
3. The undecorticated molar segment acted as better anchorage unit during the retraction period and there was no appreciable loss of anchorage in both the experimental sides.
4. The inter-canine width was increased significantly after retraction on both the experimental sides.
5. The canine tipping/angulation increased significantly post retraction in both the experimental groups. Comparatively the Piezocision group showed increased tipping to the corticotomy group but it was not significant

6. The canine rotation increased post retraction in both the experimental groups with no significant difference between both the groups.

   Based on the outcome of this study it is reasonable to conclude that

   - Both Piezocision and Corticotomy have a trend in increasing the rate of canine retraction when compared to the conventional canine retraction techniques and are minimally invasive
   - Piezocision can be a viable alternative to the moderately invasive corticotomy, if declined by the patient.
   - Also, Selective decortications can acts as an effective tool in varying the relative anchorage value of the teeth
   - An elaborative study should be conducted with a substantial increase in sample size for a conclusive evidence.

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Annexures

ANNEXURE -I

RAGAS DENTAL COLLEGE & HOSPITAL

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TO WHOMSOEVER IT MAY CONCERN

Date: 06/01/2017

From

The Institutional Ethics Board,

Ragas Dental College and Hospital,

Uthandi,

Chennai- 600119

The dissertation topic titled **"EVALUATION AND COMPARISON OF THE EFFECTIVENESS OF PIEZOCISION AND CORTICOTOMY DURING INDIVIDUAL CANINE RETRACTION – A SPLIT MOUTH STUDY."** submitted by **Dr. B.N.VINEESHA** has been approved by the Institutional Ethics Board of Ragas Dental College and Hospital.

Dr. N.S. Azhagarasan, MDS.
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ANNEXURE- II

DECLARATION OF PLAGIARISM CHECK

From,

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To

The Head of the Department

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SUB: Declaration of plagiarism check of my dissertation to be submitted to the "The TamilNadu Dr.M.G.R. Medical University"-April 2017.

I hereby declared that I have checked my dissertation for plagiarism using Small Seo Tools -plagiarism checker software on 6-1-2017 date for this dissertation. The unique content was 88% and the plagiarism content was 12%.The plagiarism content corresponds to definitions and terminologies that have to be quoted.