"ASSESS AND COMPARE THE CHANGES IN PERIODONTAL SOFT AND HARD TISSUE IN MAXILLARY AND MANDIBULAR ANTERIOR TEETH BEFORE AND AFTER ORTHODONTIC TREATMENT: A RETROSPECTIVE STUDY"

By

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Dissertation

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I, ***REG NO. IK0222005*** , a postgraduate student in Department of Periodontics, have completed my research work on the topic *"Assess and compare the changes in periodontal soft and hard tissue in maxillary and mandibular anterior teeth before and after orthodontic treatment: A retrospective study"* in the year 2022-2025.

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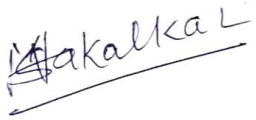

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LIST OF ABBREVIATIONS

BI	**Bleeding index**
BOP	**Bleeding on probing**
CAL	**Clinical attachment loss**
CBCT	**Cone beam computed tomography**
GBI	**Gingival bleeding index**
GCF	**Gingival crevicular fluid**
GT	**Gingival thickness**
KM	**Keratinized mucosa**
KTW	**Keratinized tissue width**
mm	**Millimeter**
OPG	**Panoramic radiograph**
PD	**Probing depth**
PI	**Plaque index**
PPD	**Pocket probing depth**
RL	**Root length**
SCTG	**Sub epithelial connective tissue graft**
SD	**Standard deviation**
VPI	**visible plaque index**

ABSTRACT

INTRODUCTION

Orthodontic tooth movement has an effect on periodontal soft and hard tissue. When forces are applied to teeth, pressure and compression zones are formed in the periodontal ligament which leads to remodeling of the periodontal structures. Periodontal parameters such as keratinized tissue width, crestal bone level and clinical crown height helps to determine this effect of orthodontic forces on periodontal health. These parameters are not routinely examined before and after orthodontic treatment, therefore patient's record can be used to obtain the required data.

Therefore, this study was designed to Assess and compare the changes in periodontal soft and hard tissue in maxillary and mandibular anterior teeth before and after orthodontic treatment retrospectively.

AIM

Assess and compare the changes in periodontal soft and hard tissue in maxillary and mandibular anterior teeth before and after orthodontic treatment.

MATERIALS AND METHODS

Orthodontic records 42 patients who had undergone orthodontic treatment for class II division 1 malocclusion were collected from Department of Orthodontics and Dentofacial orthopedics, KAHER's KLE VK Institute of Dental Sciences, Belagavi and were assessed for pre-treatment and post-treatment changes in periodontal soft and hard tissue. Keratinized tissue width (KTW) was measured on the intraoral photographs from the mucogingival line to marginal gingiva. Crestal bone height

(CBH) was measured on a panaromic radiograph (OPG) as a distance between cementoenamel junction and crest of alveolar bone. Clinical crown height (CCH) was measured on study models as a distance between gingival margin and incisal edge. Descriptive statistics, Normality of data was assessed by Shapiro – Wilk test. Pre-treatment and post-treatment values were compared with unpaired t-test. Statistical significance to be accepted at a confidence level greater than 95% ($p < 0.05$).

RESULTS

The pre-treatment and post-treatment values for all three parameters when assessed using unpaired t test showed a statistically significant difference. The CBH showed a very highly statistically significant difference with 'p' value of 0.0001 for maxillary as well as for mandibular teeth. Whereas the KTW showed a statistically significant reduction only in mandibular teeth with a p value of 0.0329. Similarly, CCH has also shown a statistically significant increase in mandibular region with p value 0.0085.

CONCLUSION

The results of our study showed that the orthodontic forces affects the hard and soft tissue support but does not always cause deleterious effect. The healthy functioning of periodontal tissue can be maintained even after the remodeling of the periodontal structures due to orthodontic forces

KEYWORDS: Periodontal soft and hard tissue, orthodontic treatment, keratinized tissue width, crestal bone height, clinical crown height.

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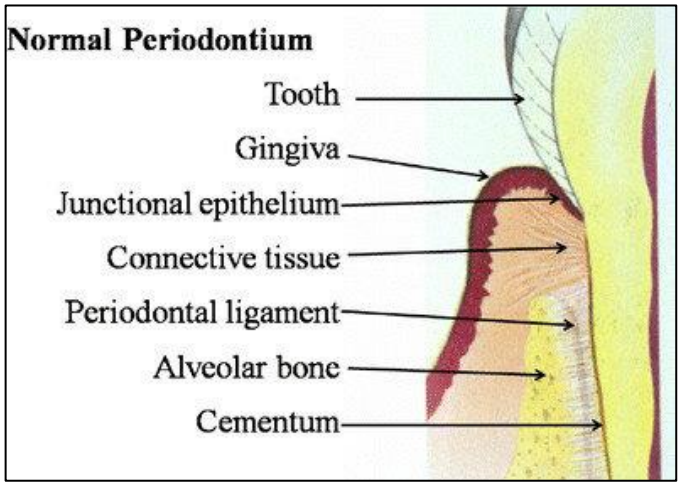
INTRODUCTION

The normal periodontium provides support that is necessary to maintain the functional integrity of teeth. This structural unit of periodontium consists of both soft tissue (gingiva, periodontal ligament) and hard tissue components (cementum, alveolar bone).



Periodontal evaluation is an important requisite prior to orthodontic therapy. Periodontal problems can be prevented by carefully assessing the patient and following strict oral hygiene maintaince.[1] Current literature states that the investing structures of the teeth like the bone, gingiva and root can be affected during orthodontic treatment leading to reduction in the crestal bone height, apical migration of the gingival margin and root resorption[2].Orthodontic therapy can also be used to treat pre-existing infra-bony defects, and correction of mucogingival problems.[3]

Periodontal health during orthodontic treatment depends on the gingival biotype, periodontal hard tissue and oral health status of the patient. The question of how much the KTW is adequate prior to orthodontic treatment is a major source of debate.[5]

The Keratinized mucosa (KM) width around natural teeth is defined as the distance between the mucogingival junction and the free gingival margin.[5]Clinically narrow band of KM is seen to be associated with apically placed gingival margin and inflammation of periodontal tissues. Lang and Löe reported that the sites where the KM is less than 2 mm, they presented with inflammation even after proper maintenance of oral hygiene. Therefore the authors reached a consensus that to maintain a healthy periodontium, 2mm of KM is must.[6]

Orthodontic treatment can lead to mucogingival problems in the anterior teeth especially the lower anterior teeth which is of concern. Hence close monitoring of the keratinized tissue width (KTW) in the lower anterior region is of outmost importance. It has been stated that KTW of 1mm or less can cause the gingival margin to shift apically[8,9].Pearson in his study conducted on plaster casts found no correlation between mandibular anterior tooth movement and gingival recession.[10]

The periodontist may be confronted with difficult clinical situation of treating recession after orthodontic treatment.[11]The final result of orthodontic treatment which is aesthetically pleasing and functionally adequate may be compromised due to recession in the lower anterior teeth.[12]

Assessing tissue response during orthodontic treatment can be challenging as measurements of the KTW are not recorded on regular basis before starting the treatment. The subjective classification is generally used to describe gingival status as adequate, reduced, or minimal. The KTW can be measured accurately from pre-treatment records like photographs and dental casts can be used for individual patient assessment and as a research tool to evaluate the impact of orthodontic managements on periodontal support.[14]Documenting the KTW from intraoral photographs and

dental casts has been mentioned previously in litrature. However their use in assessing the changes in periodontal structure during orthodontic treatment have not been validated.[15]

Also, during orthodontic treatment the tooth is displaced through bone via resorption of bone on one side and deposition on another side, meanwhile cementum maintain its integrity during lateral movements. Remodelling of bone rather than cementum actually makes the tooth movement possible.

Orthodontic tooth movement has its effect on the underlying alveolar bone. Teeth which are subjected to orthodontic treatment, are under different types of forces such as tension forces, pressure forces, compression and shear forces. These difference may express variety of effects on the alveolar bone which need to be assessed.

Literature on effect of attachment loss and alveolar bone loss post orthodontic treatment is sparse. Hence, the current study aims to assess and compare the changes in periodontal soft and hard tissue in maxillary and mandibular anterior teeth before and after orthodontic treatment.

AIMS AND OBJECTIVES

AIM OF THE STUDY:

To assess and compare the changes in periodontal soft and hard tissue in maxillary and mandibular anterior teeth before and after orthodontic treatment.

OBJECTIVES:

1. To assess and compare the difference in width of keratinized gingiva in maxillary and mandibular anterior teeth before and after orthodontic tooth movement.

2. To assess and compare the alveolar bone height changes in maxillary and mandibular anterior teeth before and after orthodontic treatment.

3. To assess and compare the changes in clinical crown height in maxillary and mandibular anterior teeth before and after orthodontic tooth movement.

REVIEW OF LITERATURE

Hixon EH et al (1970)[44] did a study on six children who had extraction of 1st premolars and required retraction of canines for the treatment of malocclusion. The results of their study have shown that during orthodontic tooth movement some amount of tipping forces are delivered due to the inherent flexion in all wires. The observations regarding the relation between root area and rate of tooth movement has presented a conclusion that though these factors affect the resultant tooth movement, they are not under control of the orthodontist. They have also concluded that the tipping movements that occur in first phase of tooth movement leads to measurable deformation of alveolar bone with compression of periodontal ligaments.

Coatoam et al, 1981[16] conducted a research on the records of 100 individuals where the buccal region of 966 teeth was assessed on how orthodontic therapy affected the keratinized gingiva width and clinical crown height on digital slides, cephalograms and plaster study casts at baseline and after completing treatment. During orthodontic treatment, certain teeth had statistically significant improvements in clinical crown height and experienced an upsurge in the keratinized tissue width; these two parameters did not change in tandem. The orthodontic adjustments to the central incisors of the maxilla ($P < 0.001$) and alteration in the size of maxillary and mandibular cuspids and the keratinized gingiva were shown to be significantly correlated ($P < 0.02$).

Bimstein et al, 1988[17] investigated modifications of the probing depth, and keratinized and attached gingiva in 54 children between the ages of 7 and 9 at 5-year intervals. Keratinized gingiva and sulcus depth were evaluated on the labial side of the incisors, and also at both sides of cuspids as well as molar.

In comparison to the deciduous teeth, the permanent teeth had a greater sulcus depth, greater keratinized tissue around their maxillary teeth, and shorter attached gingiva. When in the presence of permanent tooth the keratinized gingiva's width slightly increased and the attached gingiva's width significantly increased, while the probing depth decreased.

Polson et al, 1988[18] in his clinical investigation, reported the periodontal condition of people with uncorrected malocclusions (control) and those who had completed orthodontic therapy a minimum of ten years prior (study) was compared by inspection at six sites around the perimeter of each tooth. The findings demonstrated that the comparisons between the groups were being impacted by variations in the age and distribution within the groups. For every periodontal measure, there were no discernible variations between the groups. Thus it was determined that there was no appreciable impact of orthodontic therapy during adolescence on subsequent periodontal health.

Boyd et al, 1989[19] did a long-term study to track the periodontal health of 20 adults and 20 teenagers receiving permanent orthodontic treatment. Before beginning orthodontic therapy, ten adults with widespread periodontitis underwent periodontal surgery, and during orthodontic treatment, they got periodontal maintenance every three months. The adolescents and adults in the next group did not undergo any periodontal treatment nor did they maintain their periodontal health while undergoing orthodontic tooth movement. PI, GI, BOP and PPD, were measured at six standard sites to assess periodontal health before, during, and after orthodontic treatment. During orthodontic treatment, in the adolescent group amounts of supra-gingival debris and inflammation of the periodontal pocket were considerably greater than those of the adult group ($p < 0.05$); however, this tendency stopped being statistically

significant after the appliances were taken out. There was no discernible difference in the loss of attachment between young people and older people with healthy periodontium, and adult group with diminished but normal periodontal structures who had history of periodontal treatment. Regarding tooth loss, among the adult group receiving periodontal treatment 3 non study teeth having furcation involvements as well as pockets greater than 6 mm were lost as they developed periodontal abscesses.

Closs et al., 2007[20] outlined the connection among the quantity of keratinized tissue in adolescents at starting of orthodontic therapy and the recession of gingiva following treatment, as determined by intraoral photos along with orthodontic research models from 209 Caucasian patients undergoing non-extraction orthodontic treatment who had Class I or II malocclusion. The level of recession was assessed using a digital calliper, also the gingival margin changes following treatment were classified into three categories: apical, coronal, or unaltered. On the pre-treatment photos, the breadth of keratinized gingiva was recorded from the gingival margin to the mucogingival line. The teeth with gingival recession and the teeth with a stable gingival margin position (3.00 ± 0.61 and 3.5 ± 0.86 mm, correspondingly) had a comparable initial level of keratinized gingiva. Remarkably, the amount of keratinized tissue in the beginning was lower in gingival teeth that had coronally displaced marginal gingiva. (2.26 ± 0.31 mm). The mean value of initial keratinized gingiva for the mandibular incisors and canines did not predispose them to gingival recession.

Gastel et al., 2008[23] conducted a study comparing the microbiological and clinical aspects of orthodontic bands and brackets. There were 24 patients in this split-mouth, longitudinal study. Gingival crevicular flow rate (GCF), sub- and supra-gingival microbiology, PD, and BOP both assessed at baseline (band insertion) and throughout weeks 18, 24, and 36 (bracket bonding). The banded, bonded, as well as control sites

were statistically compared at different timelines. The aerobe/anaerobe proportion of sub- versus supra-gingival colonies dropped dramatically at the banded and bonded sites (relatively more anaerobes) while the study was on going (P <0.001). Alongside this decline, there were notable increase in PD, BOP, along with GCF. Compared to banding, these alterations happened more quickly after bonding. The only notable change that occurred 18 weeks after bands placement was a rise in PD (P <0.001). When compared to week 18, all microbiological and clinical indicators at the bonded location had altered considerably negatively by week 36 (P <0.001). The impacts were localized because the control location did not exhibit any discernible changes over time. Clinical and microbiological factors were significantly impacted by the positioning of fixed orthodontic appliances. Because wire insertion made cleaning more difficult, the alterations happened more quickly at the bonded sites than the banded sites. Banding did not have more detrimental long-term microbiological and periodontal implications than bonding.

Gomes et al., 2007[21] In their study on orthodontic appliances, after removing the appliance (mean period 7.16 ± 3.5 years), dental students' periodontal conditions were assessed by looking at their BOP, pocket probing depth (PPD), visible plaque index (VPI), gingival bleeding index (GBI), along with clinical attachment loss (CAL) of canines, premolars, banded first molars, and un-banded second molars in comparison to an untreated control group. Significant alteration was not seen in the intergroup and intragroup comparison. In the control group canines had the lowest PPD, then the molars and premolars. Premolars had lower PPD than molars, although it was comparable with the treated group canines. There were no differences in CAL between each tooth within the control group. Compared to the first molars, in the

treated group canines showed lower CAL values. The findings suggest that using orthodontic appliances does not always make periodontal disease worse.

Ristic et al., 2007[22] conducted a prospective longitudinal self-controlled research to ascertain how fixed orthodontic appliances affected the microbial makeup of sub-gingival plaque and periodontal health. Thirteen male and nineteen female teenagers who became eligible for fixed orthodontic therapy between 2002 and 2005 participated in this prospectively longitudinal self-controlled study. Before fixed appliances were placed, along with 1, 3, and 6 months after orthodontic therapy started, various periodontal indices and microbial data were measured. After the fixed appliances were fitted, all clinical and microbiological parameter values began to rise. Values peaked three months following the introduction of the fixed appliances, and then began to decline six months later during the final registration period. Adolescents receiving fixed appliance treatment may see a transitional increase in all periodontal index values and an increase in the proliferation of periodonto-pathogenic bacteria, but deeper periodontal tissues will not be harmed.

Han et al (2019)[45] compared the young patients with middle aged adults who were treated to correct anterior teeth alignment and assessed their periodontal health. Orthodontic casts, lateral cephalograms and periapical radiographs were used for the assessment. The marginal bone loss, the root resorption and tooth length showed significantly higher results in middle aged adults. While rest of the parameters had shown no difference between the groups. Thus the study concluded that in spite of the initial unfavourable periodontal status in middle aged adults, both the groups showed similar periodontal outcomes.

Dannan et al. 2010[24] sought to determine whether in orthodontically treated tooth, the extrusion process and the keratinized gingiva width are related, as well as whether orthodontic extrusion motions have an adverse effect on periodontal tissues. In 7 patients fourteen upper canines were exposed to orthodontic extrusion forces and measurements of the PPD, PI, BI, keratinized gingiva width and gingival index were made at baseline, three months, and six months, Throughout the experiment, the plaque index in addition to gingival index values increased dramatically, but the probing depth and also bleeding index readings failed to demonstrate any discernible changes. The keratinized tissue width of the examined teeth increased by a very slight 0.14 mm after six months compared to the baseline, but this variation was not statistically significant.

Khorsand et al., 2013[25] examined the periodontal parameters in individuals with active periodontitis at the conclusion of orthodontic therapy, including distance across the incisal edge and also interdental papilla, root length (RL), pocket probing depth (PPD), plaque index (PI) and lesion dimensions (depth and width). This clinical experiment included eight patients with extruded maxillary incisors, infrabony deformities, aggressive periodontal disease, and a probing depth of ≥5 mm (before and after orthodontic treatment). After periodontal therapy, orthodontic tooth movement was planned for tooth intrusion and alignment. PPD, defect depth and PI all decreased statistically significantly at T0, T3, and T6 ($P < 0.05$). The incisal margin and papillary distances and RL did not differ significantly ($P = 0.95$). Additionally, the defect width showed a substantial decline up to T3 ($P = 0.042$), but there were no discernible alterations from 3 to 6 months ($P = 0.59$). The findings demonstrated that if patients continued to attend follow-up appointments and

maintained proper oral hygiene, the concurrent orthodontic and periodontal techniques would be an effective therapy with enough stability.

Cao et al., 2015[26] in his study examined the form of the incisor bone defects and the alterations in periodontal health following combined treatment. After receiving orthodontic treatment, 14 adults with 56 extended maxillary incisors having horizontal bone abnormalities underwent guided tissue regeneration, periodontal regenerative surgery, and circumferential supra-crestal fibrotomy. Rather than a horizontal bone defect, some teeth came up with a vertical one. Between T1 and T2, there were notable improvements regarding both clinical attachment loss as well as probing pocket depth. Additionally, radiographic studies showed vertical and horizontal bone deposition of 2.15 ± 0.68 mm (P <0.05ly and 1.44 ± 0.92 mm (P <0.05) respectively. The length between the most apical region of the bone defect and the cementoenamel junction reduced by 2.11 ± 1.30 mm (P <0.05) after combination treatment. When orthodontic along with periodontal therapy were combined, the affected bone sites periodontal health improved. The effects of later directed tissue regeneration can be enhanced by bone shape that has been changed by orthodontic intrusion with fibrotomy.

Carvalho et al., 2018[27] evaluated how orthodontic tooth movement affected the periodontal tissues of patients receiving treatment for severe periodontitis. Following periodontal therapy, ten individuals (ages 25.0 ± 5.22 years) had orthodontic treatment. Monthly maintenance sessions were conducted with rigorous dental biofilm management. They were contrasted with 10 individuals who had orthodontic treatment and were in good periodontal health (ages 22.9 ± 5.23 years).

PI, and PPD, CAL, and measurements of bleeding on probing were made at baseline, four months later, and following orthodontic therapy. Statistical research showed that all clinical indicators, such as the tooth plaque index (11%), bleeding on probing (4.0%), attachment level with (0.38 mm), and pocket depth (0.29 mm), was enhanced the between baseline and four months after orthodontic treatment.. Under stringent biofilm control, the AP patients' periodontal measurements held steady during orthodontic therapy.

Wang et al., 2019[28] carried out research to evaluate how orthodontic tooth movement affected the keratinized gingiva width. The association among the displacement of the orthodontic teeth especially the change in gingival width was investigated through examining the keratinized gingival width and location of the teeth before and following orthodontic treatments. After comparing the pictures to the model, the gingival width was calculated by determining the dimension of the crown plus the keratinized gingiva. The pre and immediate post-treatment models were superimposed using Rapid Form 2006, enabling accurate measurements of the change in tooth position before to and following orthodontic movement. Additionally, a statistical analysis was conducted to examine the relationship between torque variation, keratinized gingival width, retraction and forward movement, and tooth intrusion and extrusion. The intrusion and even extrusion of the teeth did not appear to be related in terms of the breadth of the keratinized gingiva. The sensitivity of each tooth to variations in the breadth of the keratinized gingiva varies; incisor teeth significantly are more susceptible to these variations than premolars and canines. Throughout orthodontic treatment, the keratinized gingiva width can be predicted to fluctuate in response to changes in tooth position, and changes in this width should be tracked.

Lee et al., 2020[29] examined the labial recession in the anterior teeth in 45 individuals who received orthodontic treatment in order to analyse and determine the primary reasons of periodontal tissue alterations linked to labial gingival recession. To measure periodontal features, sliced images from 3-dimensional virtual scans and cone-beam computed tomography images in the region of interest were juxtaposed before and after orthodontic treatment. The jawbone, tooth location, inclination, rotation, and past orthognathic surgery were investigated as well to analyse the many parameters that may have contributed to the changes in anterior periodontal tissue. Gingival recession and tooth inclination were strongly correlated; gingival recession increased by about 0.2 mm with each 1° raised tooth inclination labially. In conclusion, the IGT, tooth position, tooth rotation, IBT as well past orthognathic surgery had no effect on labial gingival recession.

Abdelhafez et al., 2021[30] evaluated the potential impact on tissue aesthetics and the periodontium in a total of 155 individuals who never had orthodontic therapy were compared to 156 people who had undergone orthodontic therapy and were split among extraction and non-extraction subgroups. They measured the papilla height, keratinized gingival breadth, gingival recession, smile line, crestal bone scale, extent of tooth display, and proximal caries. Keratinized gingiva and the number of teeth visible showed the notable alteration. The periodontal tissues are obviously impacted by orthodontic therapy, however the negative effects seem to be negligible. Lower crestal bone levels at specific locations may be seen in patients who had orthodontic treatment; this should not be mistaken for periodontal disease.

Alkan et al., 2021[31] had done a study on 60 patients who had healthy periodontium and had undergone fixed orthodontic treatment. The keratinized tissue width (KTW) and gingival thickness (GT) for the upper and lower central incisor along with lateral

incisors and canines was assessed. Based on the STM for the maxillary incisors and mandibular incisors assessed before and after treatment by lateral cephalograms, these were separated into protrusion and retrusion groups. The intragroup pre-treatment and post treatment results showed a substantial decrease in the GT of the maxillary and mandibular anterior teeth in both the retrusion and protrusion groups, along with the KTW of the maxillary lateral incisors in the protrusion group. Both the maxillary and mandibular anterior teeth, Pearson correlation coefficient investigations showed no significant relationship between the GT changes and STM. Nonetheless, there was a positive association between STM and the KTW of teeth 13 and 41. The GT alterations were not substantially linked to STM, according to Pearson correlation coefficient studies for the maxillary as well as mandibular anterior teeth. STM did not significantly correlate with a reduction from the GT of the upper and also lower anterior teeth, but it did have a significant association with the KTW about teeth 13 and 41.

Alzoman et al., 2021[32] carried out a study to assess periodontal health immediately prior to and following orthodontic treatment and examine any confounding variables. Using the Image J 46 program, intraoral digital photos of 60 patients were taken pre and post orthodontic treatment to measure (a) the condition of the interdental papilla, (b) gingival recession, (c) keratinized tissue width. For the majority of upper teeth the KTW grew. The lower teeth, on the other hand, displayed a combination of compromised and improved KTW. The difference in clinical crown height, a marker of gingival recession, showed a tendency towards a lower clinical crown height for the majority of locations. In terms of KTW measurements and tooth movements like extrusion and intrusion movements, the maxillary left lateral incisors and canines displayed notable values. The periodontium, especially in the upper canine regions,

was found to be considerably improved by the orthodontic treatment. Similarly, it was noted that the periodontium benefited from different kinds of tooth movement.

Kumar et al., 2021[33] conducted research to evaluate how fixed orthodontic therapy affects gingival health. For 120 patients who had been planned for orthodontic treatment, extra oral radiographs and photographic records were acquired. Every patient underwent a thorough intraoral examination to document any visible plaque, clinically discernible inflammation, and gingival recession. The visible plaque and inflammation value, and gingival recession value were significantly increased after therapy. The thick gingival biotype grew while the sparse maxillary biotype declined among the maxillary and mandibular arches, according to the gingival biotype comparison. After receiving fixed orthodontic treatment, gingival recession, irritation, and plaque build -up all significantly increased. Therefore, it is important to practice frequent oral prophylaxis while undergoing orthodontic treatment.

Mehta et al., 2022[34] conducted this study to compare the changes in periodontal parameters after orthodontic treatment in 36 patients having isolated gingival recession treated with and without pre-orthodontic gingival recession coverage by sub epithelial connective tissue graft (SCTG). It was shown that in the test group number of teeth with better gingival phenotype and less hypersensitivity was statistically significant (P =.049, P =.002). Since graft stability is maintained throughout orthodontic therapy, a root covering operation may be carried out prior to the scheduled orthodontic treatment.

Tse et al., 2024[35] evaluated the impact of orthodontic movement and proclination of canine-to-canine teeth in the aesthetic zone on tissue characteristics like keratinized tissue size, mid facial gingival recessions, papilla width and height, as well as alveolar

bone height and soft tissue parameters using a prospective cohort study during the initial six to twelve months of therapy.

According to the findings of this study, 1) the rotation of the tooth into correct alignment is linked to a reduction in alveolar housing dimensions at the level of S1; 2) orthodontic rotation has minimal impact on the periodontal tissue in the aesthetic anterior region; 3) changes in the upper central incisor teeth, inclinations are linked to a reduce on mid facial recession 4) there is additionally a beneficial relationship with a rise in KTW at the level of S1.

MATERIALS AND METHODS

SOURCE OF DATA

This descriptive retrospective study was conducted on records of 42 patients who have undergone orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopaedics, KAHER's KLE V. K. Institute of Dental Sciences Belagavi. The digital measurements were made by using Digimizer software. Ethical clearance was obtained from the Ethical Committee, KAHER's KLE V.K. Institute of Dental Sciences, Belagavi before conducting the study.

INCLUSION CRITERIA:

1. Records of 42 orthodontic patients with completed class II div I malocclusion treatment.
2. Good quality pre and post orthodontic treatment records, including
    a. Photographs
    b. Panoramic radiographs
    c. Study casts
3. Patients between age group of 18-40 years.
4. Records of patients who completed their treatment in 2014-2021 time period.
5. Patients who have undergone premolar extraction.

EXCLUSION CRITERIA:

1. Records of patients whose orthodontic treatment is ongoing.
2. Records of patients who had systemic diseases like diabetes, any disorders affecting the quality of bone, etc.
3. Records of patients which are incomplete.

PERMISSIONS OBTAINED:

Permissions were obtained from Head of Department - Department of Orthodontics and Dentofacial Orthopaedics, KAHER's KLE V. K. Institute of Dental Sciences Belagavi, to use patient's records for our study purpose.

MATERIAL

1. **Photographic records-**

   Pre and post treatment photographs displaying the labial vestibule of mandibular and maxillary anterior teeth of patients who have completed orthodontic treatment.

2. **Panoramic radiographs (OPG) -**

   Pre and post orthodontic treatment OPG of patients who have undergone complete orthodontic therapy.

   The OPGs were taken with PM 2002 CC Proline (Planmeca OY, Helsinki, Finland) (filtration 2.5mm AlEquiv) using Kodak T-MAT G/RA Dental Film (Eastman Kodak, Rochester, NY, USA). All the exposed films were developed in an automatic film processor (Du¨rr, XR42-II, and Bieligheim, Germany).

3. **Study model-**

   Pre and post treatment models of complete upper and lower arch recorded by alginate impression, duplicated with dental stone into study cast.

4. **Software-Digimizer**

   It is a versatile and user-friendly image analysis software program that enables both automatic item detection using measurements of object attributes and accurate manual measurements. Digital records that are supported by Digimizer Software include: X-rays, micrographs, file formats like JPG, GIF, TIFF, BMP, PNG, WMF, EMF and DICOM files.

PARAMETERS RECORDED:

1. Width of keratinized gingiva (Picture no 3)
2. Crestal bone height (Picture no 4)
3. Clinical crown height (Picture no 5)

Methodology: The following parameters were assessed.

Width of Keratinized Gingiva

Pre and post-operative photographs were collected from the orthodontic records.

Converted them into soft copy by scanning in standardize ratio.

The measuring points were marked from gingival margin to mucogingival junction.

Width of keratinized gingiva was measured with the help of Digimizer software.

Mean of the measurement were compared and analysed statistically using paired t test.

Alveolar Bone Height

Pre and post-operative panoramic radiographs were collected from the orthodontic records.

Converted them into soft copy by scanning in standardize ratio.

The measuring points were marked from cementoenamal junction to crest of alveolar bone.

Alveolar bone height was measured with the help of Digimizer software.

Mean of the measurement were compared and analysed statistically using paired t test.

Clinical Crown Height

Pre and post-operative study models were collected from the orthodontic records.

Clinical crown height was measured with the help of geometric divider and centimetre scale, at midline of labial surface of teeth from incisal edge to the gingival margin.

Mean of the measurements were compared and analysed statistically using paired t test.

PROCEDURE:

a) Before treatment and after treatment records of patients from Department of Orthodontics and Dentofacial Orthopaedics, KAHER's KLE VK Institute of Dental Sciences, Belagavi, who had undergone complete orthodontic treatment for class II div1 malocclusion were screened. (Picture no 1)

b) The intraoral photographs and panoramic radiographs were scanned and converted into soft copy using Epson scanner.(Picture no 2)

c) Each record (Photographs or Radiographs) was analysed using the Digimizer software for recording the respective measurements and clinical crown height on dental cast was recorded using geometric divider and millimetre scale.

1. **Measurements on photographs** –
    a. The mucogingival line was demarcated on the labial surface of the frontal view photograph. (Picture no 6)
    b. Then a line is marked from this mucogingival line to the gingival margin at the midline of labial surface of each mandibular and maxillary anterior teeth.
    c. The length of this line determines the keratinized tissue width for that tooth.(Picture no 7 and 8)
2. **Measurements on OPGs**-
    a. The crestal bone height for a tooth was recorded in the interdental areas of maxillary and mandibular anterior on a panoramic radiograph.
    b. A line was drawn connecting the cementoenamel junction and crest of alveolar bone in the interdental area.(picture no 9 and 10)
    c. The length of this line determines the crestal bone height.

3. **Measurements on study models** –

    a. Clinical crown height of each tooth was measured on labial surface of maxillary and mandibular anterior.

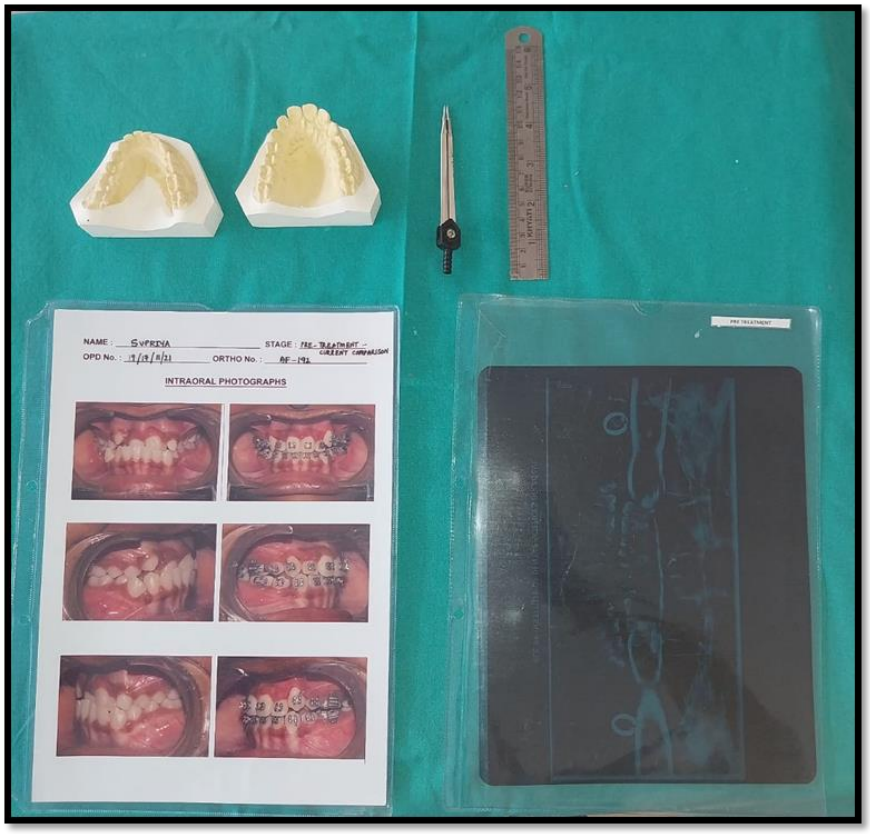
    b. The length from incisal edge to gingival margin at midline of the labial surface of each tooth has been recorded by the geometric divider.

    c. This distance recorded is measured on the centimetre scale to determine clinical crown height (Picture no 11)

STATISTICAL TESTS:

- Normality of the data will be evaluated using Shapiro–Wilk test.
- Student Paired *t*-test/Wilcoxon Matched Pairs Test will be used for pre and post comparison of groups.

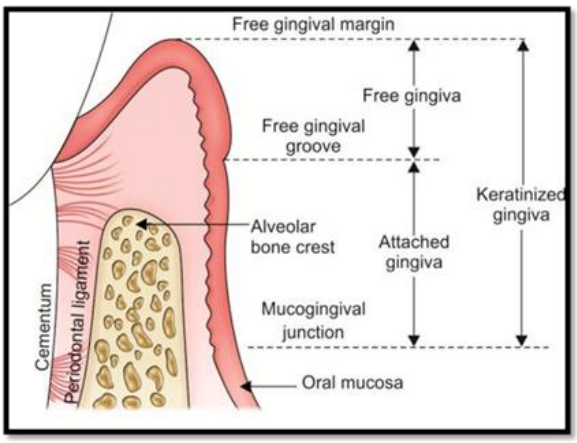
ARMAMENTARIUM USED FOR THE STUDY



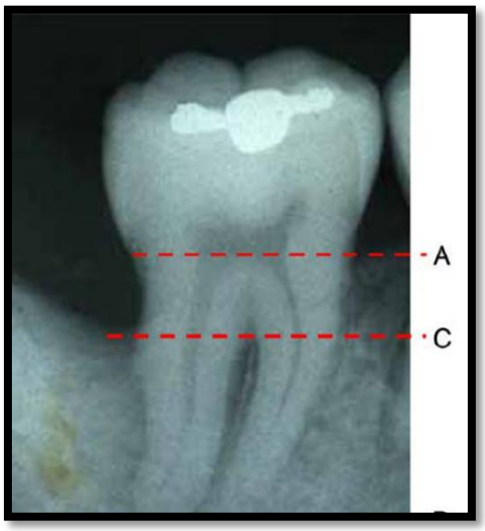
Picture no.1 - Photographs, OPGs, study casts, geometry divider, millimetre scale.

p

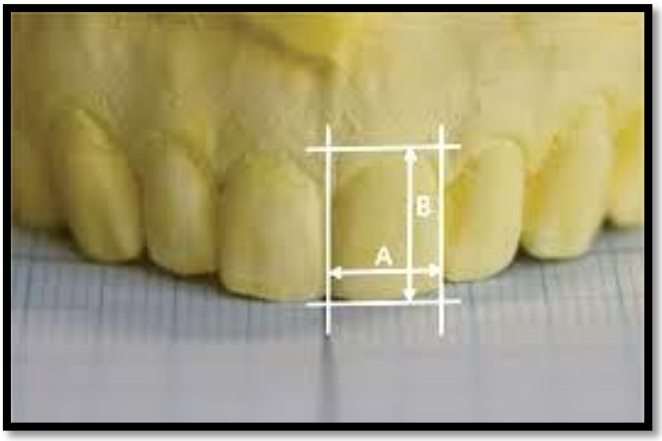
Picture no.2 - Epson scanner used for scanning the photographs and radiographs.



<u>Picture No 3:</u> Diagrammatic presentation of width of keratinized gingiva.

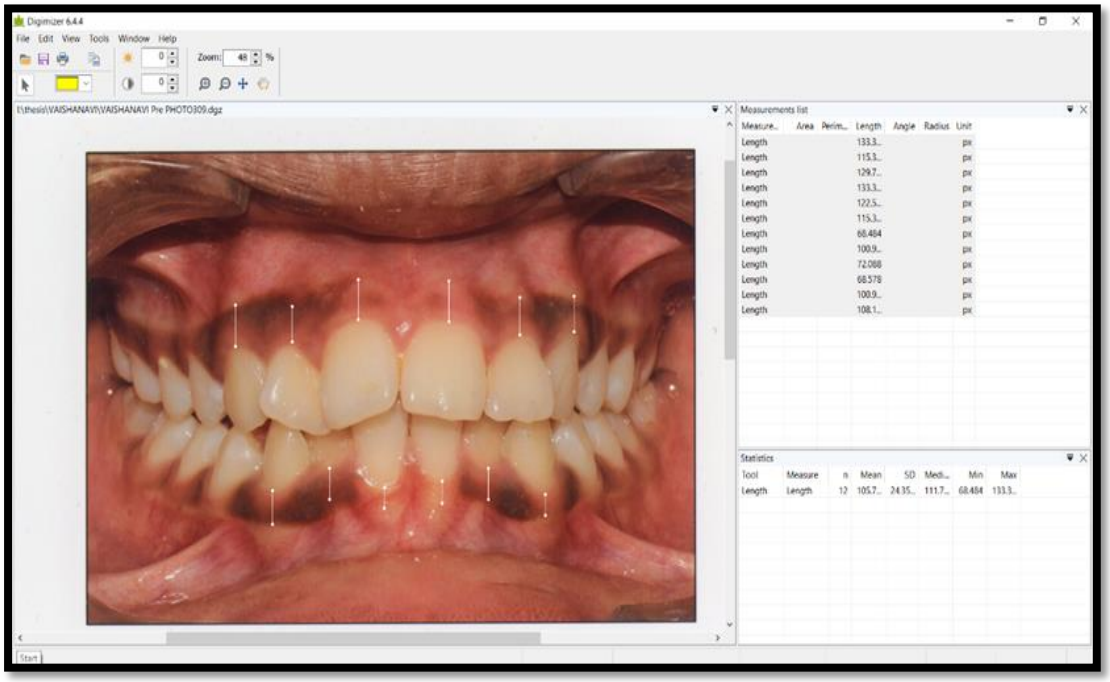


<u>Picture No 4:</u> Crestal bone height between - cementoenamal junction (A) and crest of alveolar bone (C).

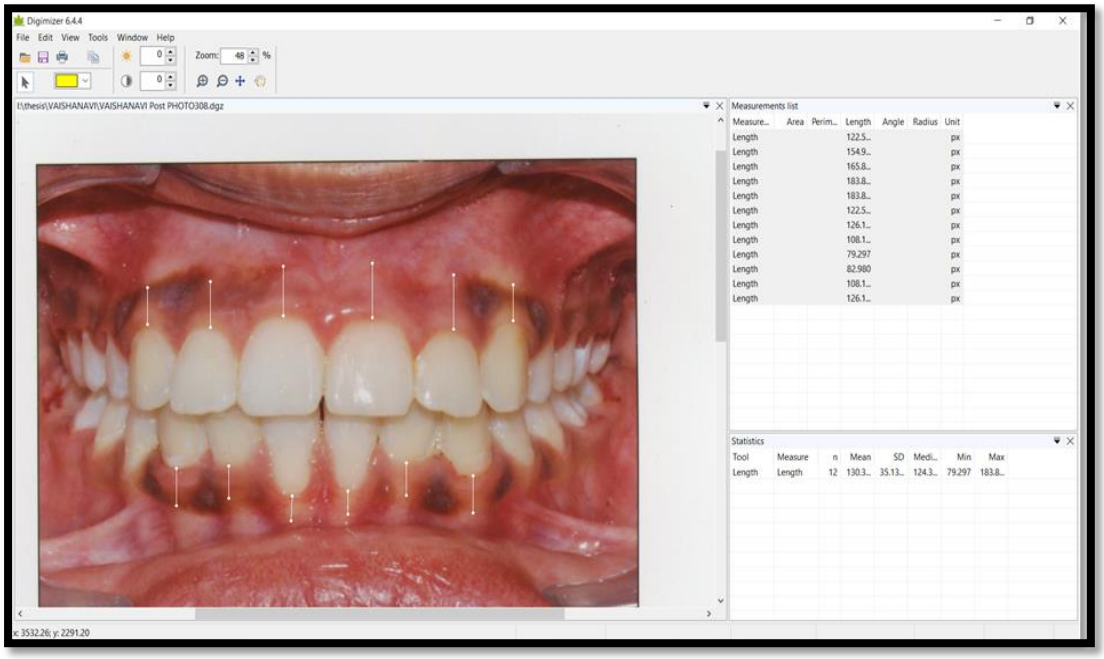


<u>Picture No 5:</u> Study model showing clinical crown height (B) and width of crown (A).

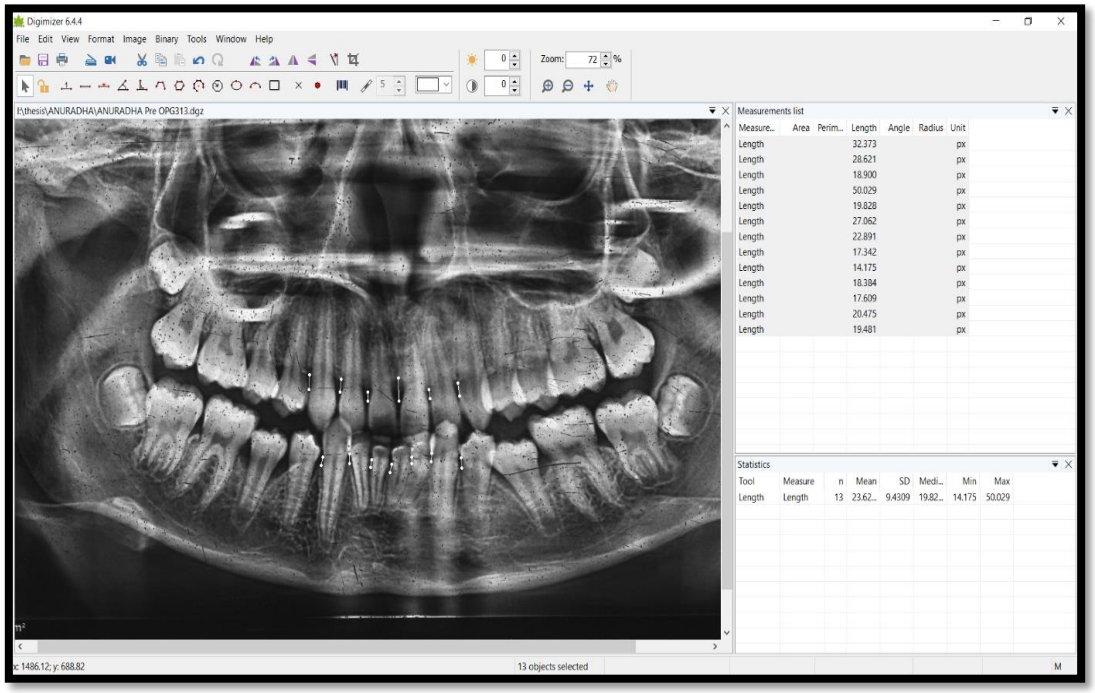
Picture No 6- Mucogingival lines marked for maxillary and mandibular arch.



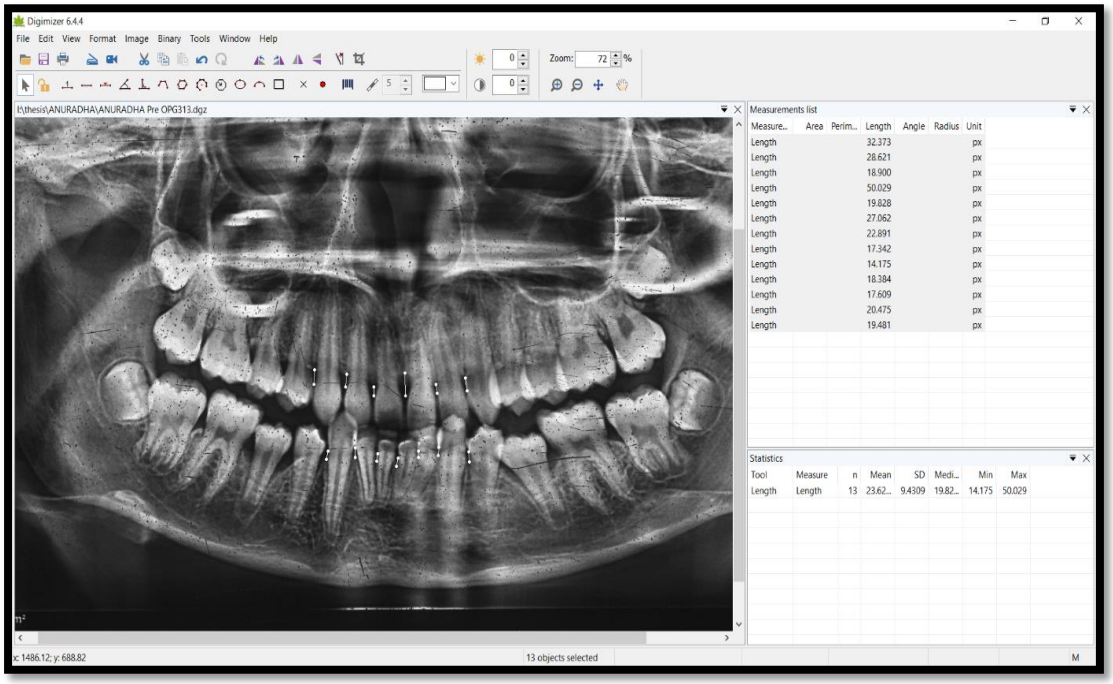
Picture No 7- Photograph showing pre-treatment measurements of keratinized tissue width.



<u>Picture No 8</u>- Photograph showing post-treatment measurements of keratinized tissue width.



<u>Picture No 9</u>- Panoramic radiograph showing pre-treatment measurements of crestal bone height



<u>Picture No 10-</u> Panoramic radiograph showing post-treatment measurements of crestal bone height

<u>Picture No 11-</u> Study casts used to measure of clinical crown height in maxilla and mandible.

RESULTS

Table 1: Comparison of before-treatment and after-treatment values of crestal bone height (in mm) of maxilla using dependent t test

Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Pre treatment	1.72	0.33					
Post treatment	0.52	0.09	-1.20	0.29	-69.77	-26.3371	0.0001*

*p<0.05

Interpretation of Table1: Crestal bone height values for maxilla were compared for before orthodontic treatment and after orthodontic treatment records. The mean value for pre-treatment records was 1.72 ± 0.33 while the mean for post-treatment record was 0.52 ± 0.09 with the mean difference was recorded as -1.20 ± 0.29. After applying the dependent t test for this data the p value was 0.0001* indicating highly statistically significant difference. As the distance between cementoenamel junction and alveolar crest is decreased, it indicates improvement in the crestal bone level in relation to cementoenamel junction. Therefore there is statistically significant improvement in crestal bone height seen in post-treatment records when compared to pre-treatment records of maxilla. (Table 1) (Graph 1)

Graph 1: Comparison of pre-treatment and post-treatment scores of crestal bone height (mm) of maxilla using dependent t test.

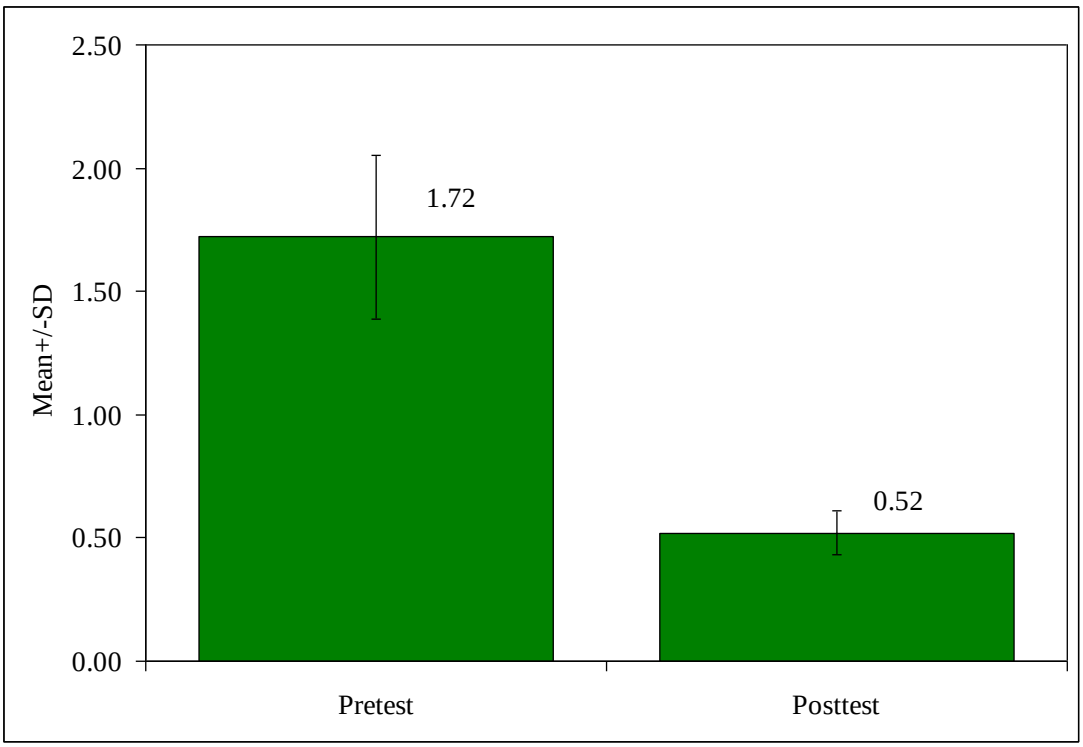


Table 2: Comparison of pre-treatment and post-treatment scores of crestal bone height (mm) of mandible using dependent t test

Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Pre-treatment	6.80	1.41					
Post-treatment	6.14	1.04	-0.66	1.06	-9.73	-4.0028	0.0001*

*p<0.05

Interpretation of Table 2: While comparing crestal bone height values of mandible before and after orthodontic treatment ,the mean of pre-treatment records was 6.80 ± 1.41 while the mean for post-treatment records was 6.14 ± 1.04 with the mean difference recorded of -0.66 ± 1.06. Highly statistically significant results were obtained after applying the dependent t test for this data with the p value of 0.0001*, which signifies improvement in crestal bone height seen in post-treatment records when compared to pre-treatment records of mandible. (Table 2) (Graph 2)

Graph 2: Comparison of before-treatment and after-treatment scores of crestal bone height (in mm) of mandible

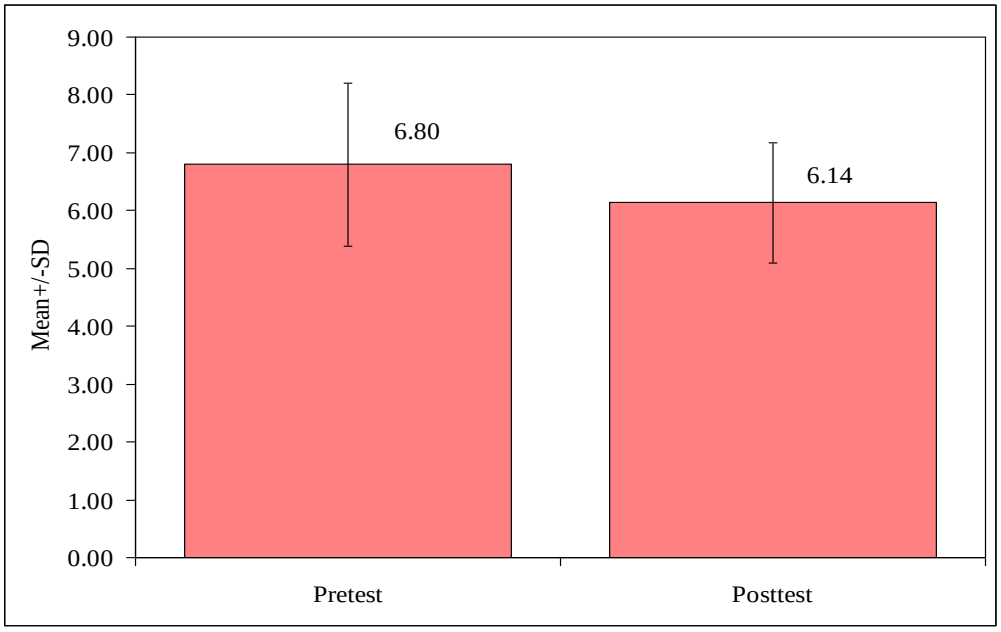


Table 3: Comparison of pre-treatment and post-treatment scores of width of keratinized tissue (mm) of maxilla and mandible by dependent t test

Side	Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Maxilla	Pre-treatment	3.84	0.71					
	Post-treatment	3.77	0.71	-0.07	0.60	-1.85	-0.6369	0.5294
Mandible	Pre-treatment	3.09	0.62					
	Post-treatment	2.80	0.61	-0.29	0.69	-9.31	-2.2437	0.0329*

*p<0.05

Interpretation of Table 3: The mean pre-treatment values of keratinized tissue width for maxillary teeth was 3.84 ± 0.71 which changed to 3.77 ± 0.71 after orthodontic treatment with mean difference of -0.07 ± 0.06. The same value for mandibular teeth for pre-treatment record was 3.09 ± 0.62, and following treatment it reduced to 0.28 ± 0.61 with mean difference of -0.29 ± 0.69. These results showed a statistically significant reduction in keratinized tissue width of mandible with p value of 0.0329*. (Table 3) (Graph 3)

Graph 3: Comparison of before-treatment and after treatment-scores of width keratinized tissue (mm) of maxilla and mandible

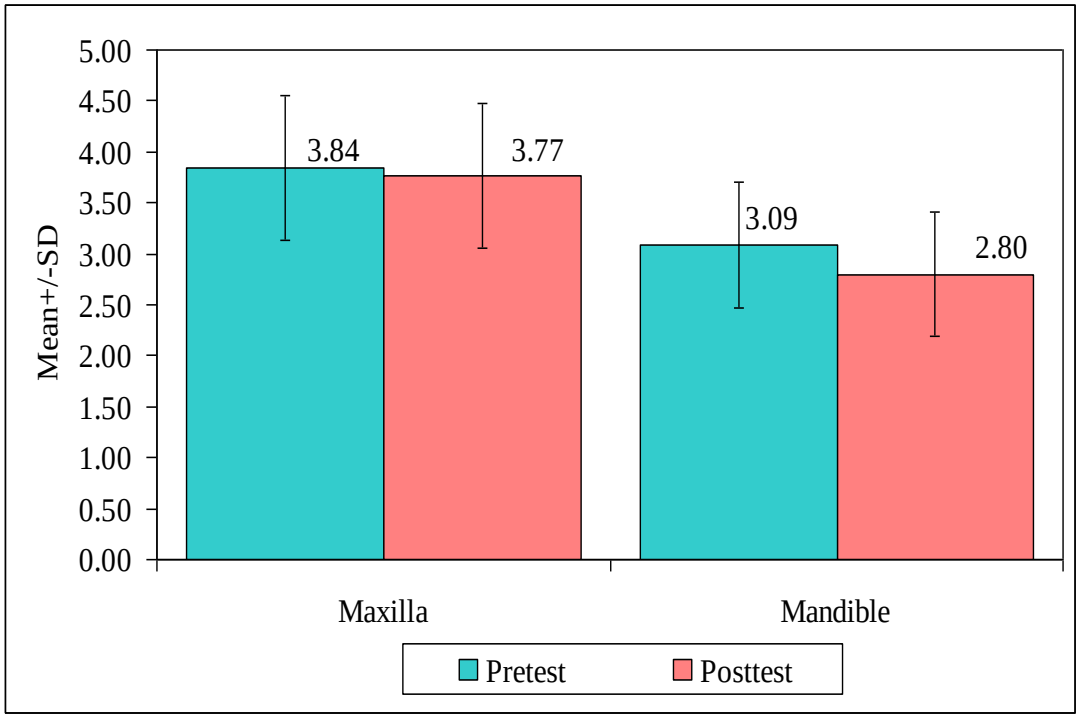


Table 4: Comparison of pre-treatment and post-treatment scores of width of keratinized tissue (mm) in each tooth by dependent t test

Tooth no.	Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Tooth 13	Pre-treatment	3.99	0.89					
	Post-treatment	3.81	0.77	-0.19	0.89	-4.68	-1.1262	0.2696
Tooth 12	Pre-treatment	3.94	0.90					
	Post-treatment	3.92	0.96	-0.02	1.10	-0.43	-0.0820	0.9352
Tooth 11	Pre-treatment	3.85	0.90					
	Post-treatment	3.79	0.74	-0.06	0.83	-1.50	-0.3742	0.7111
Tooth 21	Pre-treatment	3.72	0.84					
	Post-treatment	3.75	0.87	0.03	0.79	0.74	0.1874	0.8527
Tooth 22	Pre-treatment	3.68	0.78					
	Post-treatment	3.75	0.90	0.07	0.84	1.94	0.4573	0.6510
Tooth 23	Pre-treatment	3.84	0.81					
	Post-treatment	3.58	0.77	-0.26	0.73	-6.83	-1.9454	0.0618
Tooth 33	Pre-treatment	3.17	0.76					
	Post-treatment	2.96	0.75	-0.21	0.97	-6.65	-1.1722	0.2510
Tooth 32	Pre-treatment	3.37	0.71					
	Post-treatment	3.09	0.77	-0.28	0.84	-8.30	-1.7990	0.0828
Tooth 31	Pre-treatment	2.82	0.87					
	Post-treatment	2.64	0.87	-0.18	1.01	-6.54	-0.9864	0.3324
Tooth 41	Pre-treatment	3.02	0.92					
	Post-treatment	2.70	0.86	-0.32	1.12	-10.56	-1.5357	0.1358
Tooth 42	Pre-treatment	3.09	0.63					
	Post-treatment	2.80	0.61	-0.28	0.63	-9.18	-2.4191	0.0223*
Tooth 43	Pre-treatment	3.06	0.58					
	Post-treatment	2.61	0.67	-0.45	0.74	-14.60	-3.2675	0.0029*

Interpretation for Table 4: Keratinized tissue width was measured for each tooth separately for before and after orthodontic therapy on photographic records. The results show decrease in keratinized tissue width for almost all mandibular and maxillary anterior teeth aside from 21 and 22. Whereas statistically significant difference was found with teeth 42 and 43. The pre-treatment mean value for 42 was 3.09 ± 0.63 and post treatment mean of 2.80 ± 0.61 with mean difference of -0.28 ± 0.63 revealed a decrease that was statistically significant in keratinized tissue width

with p value of 0.0223. The pre-treatment mean value for 43 was 3.06± 0.58 and post treatment mean of 2.61 ± 0.67 with mean difference of -0.45 ± 0.74 which showed a statistically significant loss in keratinized tissue width with p value of 0.0029. (Table 4) (Graph 4)

Graph 4: Comparison of pre-test and post-test scores of keratinized tissue (mm) in each tooth

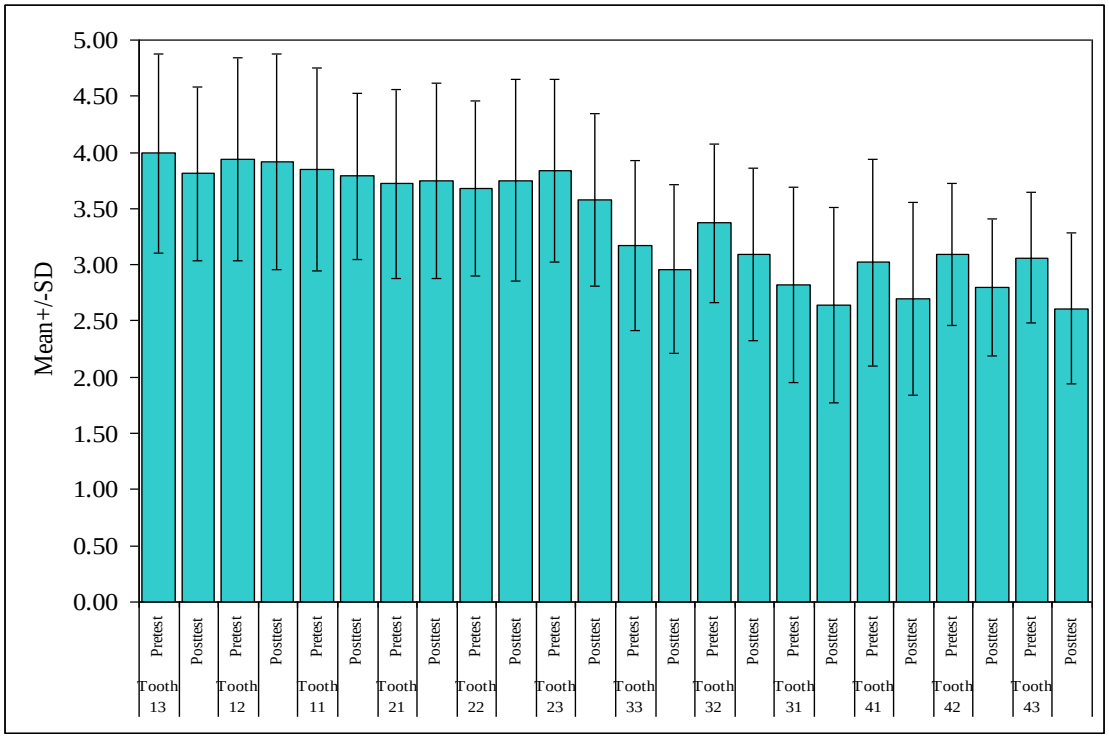


Table 5: Comparison of pre-test and post-test scores of crown height (mm) of maxilla and mandible using dependent t test

Side	Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Maxilla	Pre-treatment	8.70	1.47					
	Post-treatment	9.16	1.62	0.46	1.71	5.24	1.7293	0.0913
Mandible	Pre-treatment	7.87	1.50					
	Post-treatment	8.62	2.00	0.75	1.76	9.56	2.7644	0.0085*

*p<0.05

Interpretation of Table 5: The mean pre-treatment value for clinical crown height of 8.70 ± 1.47 increased to mean post-treatment value of 9.16 ± 1.62, which did not showed any statistically significant change. Whereas mandibular pre-treatment mean value of 7.87 ± 1.50 increased to a mean value of 8.62 ± 2.00. The mandibular teeth showed a statistically significant rise in clinical crown height with p value of 0.0085*.(Table 5) (Graph 5)

Graph 5: Comparison of pre-test and post-test scores of crown height (in mm) of maxilla and mandible

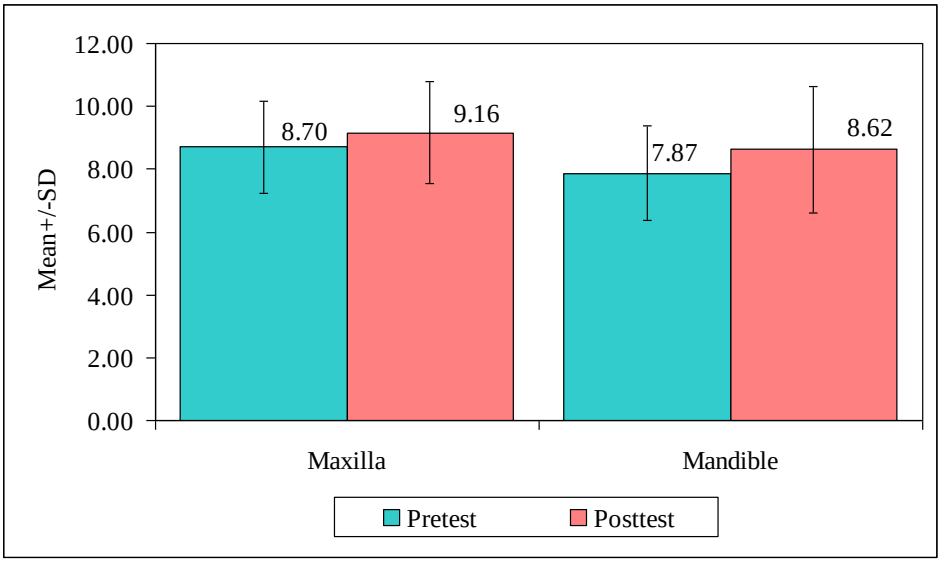


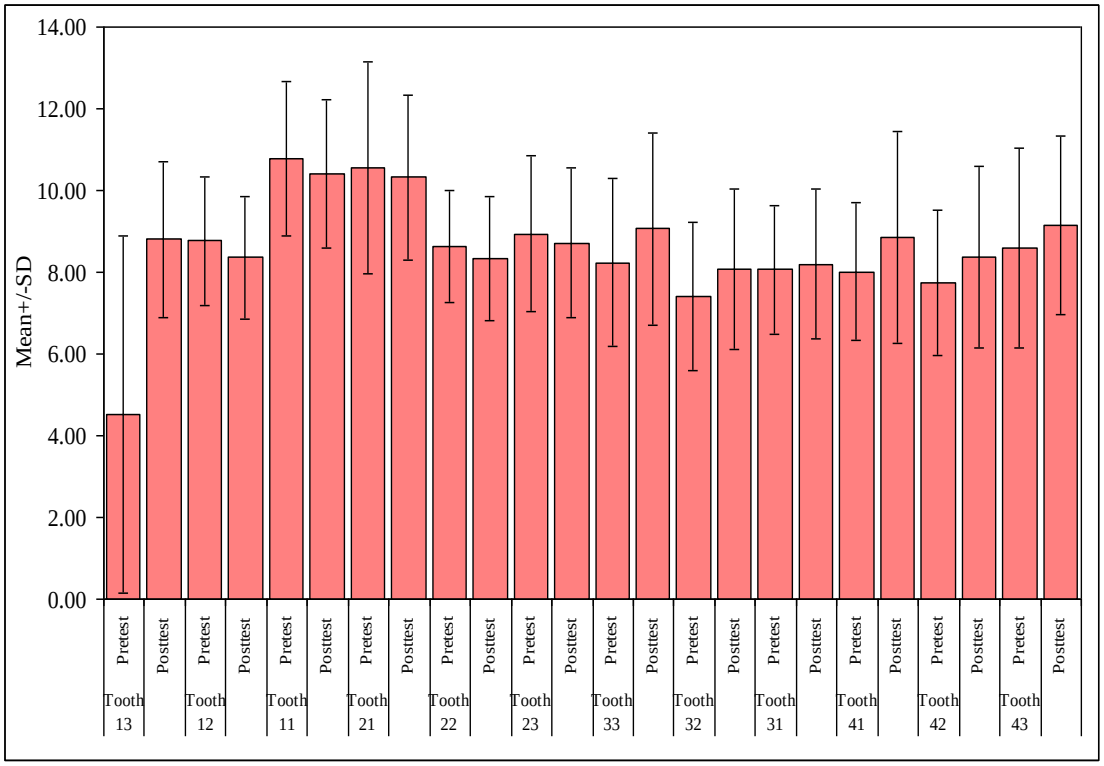
Table 6: Comparison of pre test and post test scores of clinical crown height value in each tooth by dependent t test

Tooth no.	Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Tooth 13	Pre-treatment	4.52	4.37					
	Post-treatment	8.80	1.90	4.28	5.04	94.86	5.5088	0.0001*
Tooth 12	Pre-treatment	8.77	1.57					
	Post-treatment	8.36	1.51	-0.41	1.61	-4.70	-1.6585	0.1049
Tooth 11	Pre-treatment	10.78	1.88					
	Post-treatment	10.40	1.82	-0.39	1.94	-3.58	-1.2894	0.2045
Tooth 21	Pre-treatment	10.55	2.59					
	Post-treatment	10.32	2.02	-0.23	2.74	-2.20	-0.5474	0.5871
Tooth 22	Pre-treatment	8.64	1.37					
	Post-treatment	8.35	1.52	-0.29	1.43	-3.34	-1.3047	0.1993
Tooth 23	Pre-treatment	8.94	1.91					
	Post-treatment	8.72	1.83	-0.23	2.21	-2.53	-0.6647	0.5099
Tooth 33	Pre-treatment	8.24	2.07					
	Post-treatment	9.06	2.36	0.82	2.39	10.00	2.2347	0.0309*
Tooth 32	Pre-treatment	7.41	1.82					
	Post-treatment	8.08	1.97	0.67	1.96	9.04	2.2143	0.0324*
Tooth 31	Pre-treatment	8.06	1.57					
	Post-treatment	8.19	1.83	0.13	1.84	1.67	0.4728	0.6389
Tooth 41	Pre-treatment	8.01	1.68					
	Post-treatment	8.84	2.59	0.83	2.35	10.37	2.2888	0.0273*
Tooth 42	Pre-treatment	7.74	1.78					
	Post-treatment	8.37	2.21	0.63	2.01	8.15	2.0374	0.0481*
Tooth 43	Pre-treatment	8.58	2.45					
	Post-treatment	9.16	2.18	0.59	2.09	6.85	1.8199	0.0761

*$p<0.05$

Interpretation for Table 6: Clinical crown height was measured for each tooth separately for pre and post orthodontic treatment records. The results showed clinical crown height for almost for all mandibular anterior teeth increased. Whereas statistically significant difference was found with teeth 42 and 41. The pre-treatment mean value for 42 was 7.74 ± 1.78 and post treatment mean of 8.37 ± 2.21 with mean difference of 0.63 ± 2.01 showed an improvement in clinical crown height with p value of 0.0481 which is statistically significant. The pre-treatment mean value for 41 was 8.01 ± 1.68 and post treatment mean of 8.84 ± 2.59 with mean difference of 0.83 ± 2.35 showed a statistically significant improvement in clinical crown height with p value of 0.0273. (Table 6) (Graph 6)

Graph 6: Comparison of pre-treatment and post-treatment scores of clinical crown height value of each tooth



DISCUSSION

The healthy functioning of teeth under occlusal load is because of the healthy supporting periodontal tissues. As the support to the periodontium reduces, the ability of teeth to withstand occlusal forces also reduces, because of which the alignment of the teeth is disturbed leading to drifting of teeth, labial flaring, and/or spacing. Treatment of such conditions require re-establishment of the periodontal structures. Adjunctive orthodontic treatment plays an important role in aesthetic and functional rehabilitation thereby helping to improve periodontal conditions.

Orthodontic treatment can also have undesirable effects on periodontal structures. For example, if teeth are forced to move beyond the periodontal envelope or if a tooth has weak periodontal support and is exposed to orthodontic treatment, it can cause negative effects such as root resorption, bone dehiscence or soft tissue recession.[36]

Thus the assessment of periodontal conditions before orthodontic treatment is a must for the desirable periodontal results after completion of orthodontic treatment. Also the post orthodontic assessment can give the insight about the effect of treatment on periodontium.[37] In many instances the periodontal soft and hard tissues are not routinely examined clinically before orthodontic treatment. The data in such cases can be collected from the records of patients such as photographs, casts and radiographs.

Trentin (1995) has developed a method to prove the agreement between the measurements performed clinically and those measured on records.[39] Coatoam (1981) has stated that photographs when taken with certain standards such as full cheek and lip retraction and adequate light contrast can provide the required periodontal parameters with accuracy and reproducibility.[16]

In the present study the photographs were used to measure the keratinised tissue width on the facial surface of upper and lower anterior teeth. The crestal bone height was measured on OPG as the extent from the cementoenamel junction to the crest of alveolar bone. The study casts were used to record the clinical crown height which was measured as the distance from incisal edge to the gingival margin.

Keratinized tissue width

Keratinized tissue is that part of oral mucosa which is lined by keratinized epithelium. It extends from the mucogingival junction to crest of the gingival margin.

Teeth in any malocclusion have decreased periodontal tissue envelope. In class II division I malocclusion cases there is labial flaring of maxillary anterior teeth and retroclination mandibular anterior teeth. For example in retroclined mandibular anterior teeth the crown is lingually tilted which makes the roots to be placed labially resulting in thin soft tissue with less keratinization on the labial side.[17] Therefore when forces are applied to mandibular anterior teeth in labial direction there will be a reduction in width of keratinized tissue in that region.

The outcomes of current study stated that the keratinized tissue width was maintained or slightly reduced for most of the teeth except for mandibular canine and lateral incisor. The mean value for keratinized tissue width of all the maxillary anterior teeth before treatment was 3.84 ± 0.71 which was slightly reduced after treatment to 3.77 ± 0.71. Whereas the keratinized tissue width for the mandibular anterior teeth before treatment was 3.09 ± 0.62 which was decreased to 2.80 ± 0.61. The p value was 0.0329 which was statistically significant. The mandibular lateral incisor and canine had shown a statistical significant decrease (p value 0.0223 and

0.0029 respectively) in mean keratinized tissue width with the mean difference of 0.28 for lateral incisor and 0.45 for canine.

This indicates that most of the teeth were able to withstand the orthodontic forces without much loss of keratinized tissue width.

Our study is in accordance with the study done by Howard Dorfman (1978) where he concluded that the width of keratinized tissue was reduced with labial movement while it was increased with lingual movement of mandibular incisors.[42]

Crestal bone height

Crestal bone height is assessed for determining the hard tissue support to the periodontium. The measurements are taken from the cervical margin of the tooth on the interdental surface to the crest of alveolar bone.

Person RE (2003) in his study had compared the use of OPG versus the full mouth periapical radiographs for the examination of alveolar bone changes. He concluded that the use of OPG can be preferred over the full mouth intraoral periapical radiographs.[38]

In the present study the crestal bone height was measured using the panoramic radiographs (OPG). The pre-treatment mean crestal bone levels for maxillary anterior teeth was 1.72 ± 0.33 and was reduced to 0.52 ± 0.09post treatment and the pre-treatment crestal bone levels for mandibular anterior teeth was 6.80 ± 1.41and was reduced to 6.14 ± 1.04 post treatment with the p value 0.0001 which was highly statistically significant.

This indicates that the crestal bone level was shifted from apical position to a more coronal position thereby increasing the alveolar support to the teeth.

Our outcomes are in accordance with the results of the study done by Bondevik et al (1980) where he stated that during intrusion of flared maxillary incisors there is increase in crestal bone height seen due to deposition of bone along the stretched periodontal ligaments.[43]

Our results are in contradiction with the study done by Hixon EH (1970) where he stated that the orthodontic tipping forces when applied to the mandibular anterior teeth for their up-righting during correction of class II division I malocclusion, it lead to reduction in marginal bone height on the labial side.[44] Also Han et al (2019) stated that there was a significant loss of crestal bone height in middle and young aged patients undergoing orthodontic treatment.[45]

This diversity of results of our study and the study done by Hixon EH (1970) and Han et al (2019) could be due to the change in magnitude, direction and duration of forces applied during the orthodontic treatment.[44,45] The tipping forces applied in our study were of lesser magnitude and were applied for shorter duration of time followed by bodily movement of the teeth resulting in the remodelling of the alveolar bone on the labial surface of mandibular anterior teeth and increase in the crestal bone height.

Clinical crown height

Clinical crown is the length of visible crown seen in oral cavity. It is measured from gingival margin to the incisal edge on the labial surface of teeth at mid-coronal level. The clinical crown height may change with the alteration in position of gingival margin. The apical migration of gingival margin may lead to increase in clinical crown height, predispose the teeth for gingival recession and is often associated with reduced width of keratinized tissue

Gingival recession is an apical shift of clinical attachment level exposing the root surface. It is an undesirable sequel after orthodontic treatment caused due to application of excessive orthodontic forces exceeding beyond the adaptive capacity of periodontium.

In the present study the mean of pre-treatment clinical crown height for maxillary anterior was 8.70 which increased to 9.16 after treatment which was not statistically significant. Whereas the mean of the clinical crown height in the lower anterior teeth before-treatment was 7.87 and after-treatment was 8.62 with the mean difference of 0.75 and p value of 9.56 which was statistically significant.

Thus the results of our study showed increase in clinical crown height in both maxillary and mandibular anterior teeth without causing gingival recession.

The apical migration of gingiva which was related to increase in clinical crown height and gingival recession was studied by Closs et al (2006). He had stated that with the apical migration of gingival margin, the clinical crown height was increased but keratinized tissue width was not significantly altered.[20]

Lee et al (2020) assessed various periodontal factors and their association with gingival recession, where he stated that that initial gingival thickness, bone thickness, tooth position and tooth rotation are not greatly associated with gingival recession. Whereas lingual tooth inclination has shown association with the labial gingival recession after orthodontic tooth movement.[29] The findings of this study have concluded that for every 1 degree increase in lingual inclination leads to increase in labial gingival recession by 0.2 mm.

The remodelling of periodontium around a tooth under orthodontic forces is mediated by the tension and compression of periodontal ligaments. The remodelling of alveolar bone also follows the Wolf's law, which states that the bone remodelling can be triggered by the stresses applied to the bone within physiological limits.[46] Therefore the ultimate result of complete periodontal health around the tooth which is under stress during orthodontic treatment is dependent on several factors including the magnitude, duration and direction of orthodontic forces along with the periodontal conditions such as hard and soft tissue support and trauma from the occlusion before starting the orthodontic treatment.

One more important factor that can affect the outcome of the orthodontic treatment is oral hygiene maintenance by patients. The orthodontic treatments are generally of longer duration and the presence of orthodontic appliances hampers the adequate tooth brushing by the patient leading to plaque accumulation and inflammation of gingival and periodontal tissue. This inflamed periodontal tissue probably shows a reduced capacity to withstand the orthodontic forces.

In the present study the results of all three parameters: keratinised tissue width, crestal bone height and clinical crown height collectively showed that with the health and support of hard and soft tissues of the periodontium, teeth are able to withstand the orthodontic forces better.

After orthodontic treatment the width of keratinized tissue was maintained in maxillary region where as in mandibular anterior region there was reduction in the keratinized tissue width. Therefore the results suggest that careful attention should be given to keratinized tissue width in mandibular anterior region to avoid the unfavourable outcomes.

Crestal bone height was increased in both the maxillary as well as mandibular region after orthodontic treatment. Orthodontic treatment has helped to increase the alveolar support of the teeth, while correcting the malocclusion. The increase in clinical crown height could also be because of achieving the complete eruption and correct position of the mal-aligned teeth.

Thus, with the limitations of the study it can be concluded that orthodontic treatment not only improves the aesthetics and function of the teeth but may also have a role in improving the periodontal soft and hard tissue status.

LIMITATIONS

The present study is a retrospective study conducted on the records of patients with Class II division 1 malocclusion who had completed their orthodontic treatment. Several confounding factors such as oral hygiene maintenance, compliance of patient to the instructions or any other history which can affect the periodontal structure and ultimately change the outcome of the given treatment may be present. The assessment of posterior teeth was challenging with the available records, thus using advanced diagnostic techniques, the records with more insight on periodontal outcome can be used for further studies.

The measurements in the present study were taken from photographs and panoramic radiographs, which are two-dimensional images so the parameters such as the thickness of gingiva or the buccal and lingual cortical plate thickness are not assessed during the study. These parameters can be analysed using the three-dimensional records such as cone beam computed tomography (CBCT) or intraoral digital scanners.

Therefore in future to have a complete overview of effect of various types orthodontic treatments for various types of malocclusions, long term clinical studies evaluating different periodontal parameters for a larger number of samples are needed.

SUMMARY AND CONCLUSION

This retrospective analysis was conducted using the records of forty-two individuals who had received orthodontic treatment to rectify their Angle's Class II division 1 malocclusion.

The crestal bone height on the panoramic radiograph, the clinical crown height on the subject's models, and the keratinized tissue breadth on the picture were used to measure the periodontal support.

After evaluation it has been seen that there was decrease in the soft tissue support of the periodontium mainly in mandibular anterior teeth where the tissue thickness is generally less with labially tipping roots. Whereas interdental crestal bone level increased indicating improved osseous support. As the teeth are fully erupted and are in the correct position in the arch, the clinical crown height was also seen to be increased.

The results of our study showed that the orthodontic forces affects the hard and soft tissue support but does not always cause deleterious effect. The healthy functioning of periodontal tissue can be maintained even after the remodelling of the periodontal structures due to orthodontic forces.

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ANNEXURES

ETHICAL CLEARANCE CERTIFICATE.

Research and Ethics Committee
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CERTIFICATE

This is to Certify that the synopsis titled

Assess and Compare the changes in Periodontal soft and hard tissues in maxillary and mandibular anterior teeth before and after orthodontic treatment: A Retrospective study *Submitted by*

Dr. REG NO. IK0222005 *P. G. Student /*

Staff, Guided by _____ *from Department of*

Periodontics *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 9/4/25

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

MEMBER SECRETARY
Research & Ethical Committee
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BELAGAVI.

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
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Chairman
Research and Ethical Committee
KLE VK Institute of Dental Sciences
Belgaum

PLAGIARISM REPORT.

Scientific Correspondence and Review Committee

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Date : 18/4/2025 Serial No. : 426

PLAGIARISM CHECK REPORT

Name of the Applicant : REG NO. IK0222005
UG / PG / Ph.D / Staff : PG
Batch & Year : 2022-2025
Department : Department of Periodontics

The soft copy of Research Work / Manuscript by REG NO. IK0222005 . entitled

"To assess & compare the changes in periodontal soft & hard tissue in maxillary and mandibular anterior teeth before & after orthodontic treatment - A retrospective study."

under the guidance of ..... I .....has been submitted for Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of .....6.....%, which is **within / not within** the acceptable limits of 10% as per the UGC guidelines.

18/04/2025

Member Secretary
Scientific Correspondence and Review Committee
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KAHER-Belagavi

Chairman
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BIOSTATISTICIAN CERTIFICATE.

K L E
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Biostatistics Clearance Certificate

This is to certify that Biostatistics aspect of the Dissertation/Research work of **REG NO. IK0222005** **Post Graduate Student**, under the guidance of **Professor, Department of Periodontics**, Entitled **"Assess and Compare the Changes in Periodontal Soft and Hard Tissue in Maxillary and Mandibular Anterior Teeth Before and After Orthodontic Treatment: A Retrospective Study."** has been done under my guidance and completed satisfactorily.

Place: Belagavi
Date:

Name & Signature of Biostatistician

Dr. S. B. Javali. Ph.D.
Professor In Statistics
Department of Community Medicine
JSM KLE International Medical Programme
BELAGAVI-590010.

WAIVER FORM.

Department of Periodontics

KAHER V.K Institute of Dental Sciences, Nehru Nagar, Belagavi.

Assess and compare the changes in periodontal soft and hard tissue in maxillary and mandibular anterior teeth before and after orthodontic treatment: A Retrospective study."

Waiver of informed consent form

Records of orthodontically treated patients will be collected from the Department of Orthodontics and Dentofacial Orthopedics. However, I assure that confidentiality of the participant information will be ensured and no identifying information related to the study participants will be disclosed in any report/publication arising from the study.

POST GRADUATE STUDENT
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PROFORMA

DEPARTMENT OF PERIODONTICS,

KAHER'S KLE's V.K. INSTITUTE OF DENTAL SCIENCES,

BELAGAVI.

a) Photographic measurements

Width of keratinized gingiva	**Pre-treatment records**	**Post treatment records**
Mean of mandibular anterior teeth measurements		
Mean of maxillary anterior teeth measurements		

b) Radiographic measurements

Alveolar bone height	**Pre-treatment records**	**Post treatment records**
Mean of mandibular anterior teeth measurements		
Mean of maxillary anterior teeth measurements		

c) Study model records

Clinical crown height	**Pre-treatment records**	**Post treatment records**
Mean of mandibular anterior teeth measurements		
Mean of maxillary anterior teeth measurements		

MASTER CHART.

POST CRESTAL BONE HEIGHT (mm)

sl no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1	13d	7.784	7.617	7.018	4.432	3.562	6.275	6.388	9.044	8.655	8.499	7.873	3.877	6.382	5.574	5.574	6.935	8.609	7.338	8.002	8.339	6.591	7.460	7.988	7.617	7.018	4.432	3.562	6.275	6.388	8.339	6.591	5.212	5.432	7.100	6.741	6.741	7.767	6.123	7.603	15.245	9.770
2	12d	7.383	7.377	5.093	5.954	5.838	5.233	8.953	4.743	8.294	11.167	6.957	5.239	6.382	8.152	8.152	5.374	9.609	9.002	9.806	6.449	6.570	8.506	7.150	7.377	5.093	5.954	5.838	5.233	8.953	6.449	6.570	5.872	6.905	4.663	8.345	8.345	8.602	4.374	9.737	10.417	14.315
3	11d	4.376	11.177	6.036	5.641	4.580	5.221	6.932	9.016	9.016	8.499	10.435	4.636	6.382	6.701	6.701	4.627	9.609	7.288	6.658	5.301	6.329	6.465	6.770	11.177	6.036	5.641	4.580	5.221	6.932	5.301	6.329	4.877	5.880	3.900	5.907	5.907	7.845	5.949	6.137	9.910	9.222
4	21m	4.746	6.598	5.718	5.676	5.505	6.695	5.181	8.326	9.016	8.487	9.223	7.410	5.330	5.242	5.242	6.554	8.565	7.400	6.790	10.988	5.835	5.725	6.353	6.598	5.718	5.676	5.505	6.695	5.181	10.988	5.835	6.648	6.948	5.717	5.960	5.960	4.808	6.139	8.679	11.055	9.436
5	22m	4.955	4.432	5.753	5.024	3.302	2.870	3.639	6.131	9.016	8.487	7.347	4.458	6.038	5.310	5.310	6.903	9.570	9.002	8.002	7.988	4.205	7.068	7.150	4.432	5.753	5.024	3.302	2.870	3.639	7.988	4.205	7.167	3.917	4.284	3.365	3.365	6.021	7.750	8.297	9.139	4.941
6	23m	6.745	8.661	6.996	5.676	6.808	4.984	7.852	11.923	11.179	6.804	10.435	6.499	4.623	6.794	6.794	9.472	8.565	9.776	7.280	6.449	7.400	4.692	6.638	8.661	6.996	5.676	6.808	4.984	7.852	6.449	7.400	4.891	3.537	7.170	4.726	4.726	4.634	5.321	5.944	9.726	5.442
7	23d	7.452	11.166	3.509	4.263	4.637	5.612	7.677	8.365	14.786	5.434	9.060	7.881	8.516	8.980	8.980	6.233	8.048	9.431	5.061	7.459	6.329	5.978	7.661	11.166	3.509	4.263	4.637	5.612	7.677	7.459	6.329	5.640	4.673	7.808	3.879	3.879	8.270	4.711	9.039	8.120	7.171
8	33d	6.745	9.150	4.776	6.276	5.838	7.783	9.804	7.934	11.901	5.434	6.040	5.992	7.091	5.948	5.948	8.815	8.063	8.574	15.092	8.024	7.173	6.340	6.717	9.150	4.776	6.276	5.838	7.783	9.804	8.024	7.173	7.008	5.840	6.773	5.180	5.180	6.657	7.885	8.649	7.764	7.618
9	33m	7.383	9.389	5.093	8.554	4.222	4.670	8.528	8.663	13.343	6.270	5.249	6.733	4.042	7.733	7.733	7.744	8.295	7.300	10.219	8.331	6.575	6.484	6.924	9.389	5.093	8.554	4.222	4.670	8.528	8.331	6.575	6.763	5.550	5.330	10.893	10.893	8.145	7.011	9.017	7.613	6.710
10	32m	5.463	11.166	6.044	6.648	6.800	4.922	8.953	6.501	10.458	8.041	8.639	6.245	5.365	5.993	5.993	5.575	11.077	7.338	8.434	9.853	6.095	4.692	10.076	11.166	6.044	6.648	6.800	4.922	8.953	9.853	6.095	6.107	4.479	5.318	3.938	3.938	7.802	6.185	8.657	6.852	6.769
11	31m	7.048	6.344	4.765	7.215	6.187	5.835	6.444	7.573	13.704	9.868	9.070	7.058	6.746	6.746	6.746	7.810	9.109	8.743	6.717	7.195	6.490	4.625	7.661	6.344	4.765	7.215	6.187	5.835	6.444	7.195	6.490	4.745	5.840	5.318	6.411	6.411	5.560	7.921	10.149	9.389	5.884
12	41d	6.687	6.364	5.753	5.676	5.222	7.342	5.536	8.326	8.655	7.801	9.960	7.401	5.684	5.684	5.684	7.365	8.048	6.530	8.922	7.545	6.575	6.570	6.484	6.364	5.753	5.676	5.222	7.342	5.536	7.545	6.575	6.210	6.210	4.623	5.135	5.135	5.180	6.619	8.297	5.082	5.884
13	42d	7.048	6.344	4.765	7.215	6.187	5.835	6.444	7.573	13.704	9.868	9.070	7.058	6.746	6.746	6.746	7.810	9.109	8.743	6.717	7.195	6.490	4.625	7.661	6.344	4.765	7.215	6.187	5.835	6.444	7.195	6.490	4.745	5.840	5.318	6.411	6.411	5.560	7.921	10.149	9.389	5.884
14	43d	11.739	11.739	8.587	7.518	9.711	5.267	8.136	11.008	5.726	6.501	4.277	4.858	5.330	7.575	7.575	6.287	7.435	7.764	7.764	11.297	5.984	6.483	5.878	11.739	8.587	7.518	9.711	5.267	8.136	11.297	5.984	6.885	6.958	4.451	11.297	5.984	6.483	5.878	6.885	6.958	4.451

PRE CRESTAL BONE HEIGHT (mm)

sl no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1	13d	9.187	9.187	5.013	9.819	7.829	8.702	6.867	12.232	4.636	8.774	5.212	5.432	7.100	6.741	6.741	7.767	6.123	7.325	7.325	5.987	8.633	8.906	7.186	9.187	5.013	9.819	7.829	8.702	6.867	5.987	8.633	7.144	10.813	7.963	5.987	8.633	8.906	7.186	7.144	10.813	7.963
2	12d	1.235	1.235	0.585	0.712	0.671	0.767	0.869	1.098	0.627	0.758	0.587	0.691	0.466	0.835	0.835	0.860	0.437	0.602	0.602	0.795	0.664	0.579	0.744	1.235	0.585	0.712	0.671	0.767	0.869	0.795	0.664	0.456	0.966	0.708	0.795	0.664	0.579	0.744	0.456	0.966	0.708
3	11d	0.817	0.817	0.526	0.698	0.637	0.665	1.065	1.226	0.627	0.743	0.488	0.588	0.390	0.591	0.591	0.785	0.595	0.749	0.749	0.683	0.716	0.398	0.547	0.817	0.526	0.698	0.637	0.665	1.065	0.683	0.716	0.600	0.888	0.600	0.683	0.716	0.398	0.547	0.600	0.888	0.600
4	21m	0.975	0.975	0.718	0.612	0.447	0.744	1.153	1.389	0.954	0.793	0.665	0.695	0.572	0.596	0.596	0.481	0.614	0.814	0.814	0.803	0.804	1.058	0.588	0.975	0.718	0.612	0.447	0.744	1.153	0.803	0.804	0.651	0.926	0.912	0.803	0.804	1.058	0.588	0.651	0.926	0.912
5	22m	0.904	0.904	0.418	0.606	0.600	0.670	0.687	0.952	0.519	0.722	0.717	0.392	0.428	0.336	0.336	0.602	0.775	0.472	0.472	0.772	0.910	0.607	0.546	0.904	0.418	0.606	0.600	0.670	0.687	0.772	0.910	0.547	0.695	0.503	0.772	0.910	0.607	0.546	0.547	0.695	0.503
6	23m	1.041	1.041	0.607	0.901	0.687	0.700	0.539	1.101	0.437	0.797	0.489	0.354	0.717	0.473	0.473	0.463	0.532	0.901	0.901	0.530	0.872	0.698	0.725	1.041	0.607	0.901	0.687	0.700	0.539	0.530	0.872	0.735	0.674	0.858	0.530	0.872	0.698	0.725	0.735	0.674	0.858
7	23d	1.021	1.021	0.460	0.938	0.660	0.454	1.151	1.019	0.983	0.794	0.564	0.467	0.781	0.388	0.388	0.827	0.471	0.967	0.967	0.461	0.664	0.647	0.715	1.021	0.460	0.938	0.660	0.454	1.151	0.461	0.664	0.882	0.656	0.767	0.461	0.664	0.647	0.715	0.882	0.656	0.767
8	33d	0.842	0.842	0.376	0.856	0.570	0.627	0.979	1.039	0.709	0.869	0.701	0.584	0.677	0.518	0.518	0.666	0.788	0.923	0.923	0.461	0.494	0.563	0.452	0.842	0.376	0.856	0.570	0.627	0.979	0.461	0.494	0.498	0.811	0.648	0.461	0.494	0.563	0.452	0.498	0.811	0.648
9	33m	0.970	0.970	0.488	0.734	0.597	0.532	0.898	0.832	0.873	0.857	0.676	0.555	0.533	1.089	1.089	0.814	0.701	0.967	0.967	0.494	0.669	0.887	0.511	0.970	0.488	0.734	0.597	0.532	0.898	0.494	0.669	0.547	0.889	0.618	0.494	0.669	0.887	0.511	0.547	0.889	0.618
10	32m	0.971	0.971	0.467	0.979	0.643	0.592	0.852	0.816	1.038	0.801	0.611	0.448	0.532	0.394	0.394	0.780	0.619	0.707	0.707	1.047	0.757	0.658	0.766	0.971	0.467	0.979	0.643	0.592	0.852	1.047	0.757	0.905	0.772	0.562	1.047	0.757	0.658	0.766	0.905	0.772	0.562
11	31m	0.818	0.818	0.543	0.898	0.980	0.836	0.735	0.621	1.009	1.181	0.475	0.584	0.532	0.641	0.641	0.556	0.792	1.400	1.400	0.683	0.763	0.772	0.588	0.818	0.543	0.898	0.980	0.836	0.735	0.683	0.763	0.995	0.810	0.676	0.683	0.763	0.772	0.588	0.995	0.810	0.676
12	41d	0.612	0.612	0.517	0.779	0.888	0.770	1.199	0.803	0.682	0.736	0.621	0.621	0.462	0.513	0.513	0.518	0.662	0.884	0.884	0.462	0.817	0.530	0.887	0.612	0.517	0.779	0.888	0.770	1.199	0.462	0.817	0.791	0.825	0.770	0.462	0.817	0.530	0.887	0.791	0.825	0.770
13	42d	0.818	0.818	0.543	0.898	0.980	0.836	0.735	0.621	1.009	1.181	0.475	0.584	0.532	0.641	0.641	0.556	0.792	1.400	1.400	0.683	0.763	0.772	0.588	0.818	0.543	0.898	0.980	0.836	0.735	0.683	0.763	0.995	0.810	0.676	0.683	0.763	0.772	0.588	0.995	0.810	0.676
14	43d	0.612	0.612	0.517	0.779	0.888	0.770	1.199	0.803	0.682	0.736	0.621	0.621	0.462	0.513	0.513	0.518	0.662	0.884	0.884	0.462	0.817	0.530	0.887	0.612	0.517	0.779	0.888	0.770	1.199	0.462	0.817	0.791	0.825	0.770	0.462	0.817	0.530	0.887	0.791	0.825	0.770

PRE Clinical Crown Height value

sl no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
13	8.98	0.30	0.28	0.30	0.26	0.29	0.29	0.28	0.26	0.30	0.18	0.27	0.33	0.24	0.25	0.33	0.38	0.24	0.25	0.25	0.26	0.37	10.18	9.79	9.84	7.31	7.31	9.17	8.58	6.08	7.75	10.68	8.91	9.19	10.06	8.34	9.88	8.17	7.14	7.47	8.72	10.18
12	6.43	9.64	7.62	8.00	7.67	8.84	8.41	7.54	8.26	9.77	10.09	7.33	6.91	6.85	8.97	8.97	10.31	8.67	7.64	7.67	7.94	10.82	11.76	7.99	7.59	7.81	7.81	9.88	12.03	6.85	8.02	11.66	8.36	9.72	9.08	10.97	11.14	10.17	6.53	8.06	6.98	11.76
11	10.31	10.72	10.35	10.30	9.90	11.54	10.89	10.09	8.91	10.15	11.28	9.59	10.94	9.07	12.64	12.64	15.08	9.00	10.19	9.51	10.80	15.01	13.56	9.31	10.97	8.82	8.82	12.77	15.37	8.69	8.84	13.19	10.64	10.01	11.08	9.42	12.26	8.83	7.19	10.36	10.33	13.56
21	0.00	11.15	10.52	11.18	9.82	10.80	10.89	10.56	9.78	11.30	6.68	10.13	10.94	9.07	12.53	12.53	14.49	9.00	9.53	9.51	9.66	14.13	13.35	9.98	10.78	9.32	9.32	12.77	16.84	7.17	9.16	14.36	10.14	11.69	11.41	10.23	11.76	8.66	9.73	9.87	9.16	13.35
22	8.53	7.15	8.28	7.87	7.18	8.59	8.52	5.85	8.69	10.44	9.39	7.76	7.49	6.93	9.31	9.31	10.19	8.26	7.64	6.37	7.17	10.45	10.39	8.27	7.50	7.43	7.43	9.14	11.71	6.41	8.07	11.32	9.52	9.81	9.08	9.97	10.27	9.00	9.07	8.19	8.43	10.39
23	8.42	10.40	8.95	9.54	6.20	9.17	8.60	5.47	7.28	8.91	11.98	8.73	10.44	8.00	11.95	11.95	11.70	9.11	8.99	8.86	7.10	11.18	9.11	8.67	11.02	6.80	6.80	9.77	2.94	7.39	8.05	10.61	8.61	8.23	10.47	10.42	10.00	11.66	8.44	6.44	8.14	9.11
mean for maxilla	7.11	8.23	7.67	7.86	6.84	8.21	7.93	6.63	7.20	8.48	8.26	7.30	7.84	6.69	9.29	9.29	10.36	7.38	7.37	7.03	7.15	10.33	11.39	9.00	9.62	7.92	7.92	10.58	11.24	7.10	8.32	11.97	9.36	9.77	10.20	9.89	10.88	9.41	8.02	8.40	8.63	11.39
33	7.31	8.56	9.05	6.70	6.03	7.61	6.90	9.71	8.80	12.17	5.37	9.29	7.11	8.50	9.66	9.66	10.67	8.65	7.81	10.45	8.14	13.16	8.15	8.75	4.35	6.30	6.30	7.84	2.16	8.48	6.55	12.62	9.76	7.09	9.75	8.98	7.29	8.93	5.80	8.85	8.68	8.15
32	9.53	6.48	8.04	5.63	6.85	7.04	6.79	6.70	8.53	10.83	8.55	7.49	6.82	7.67	10.46	10.46	7.52	7.02	7.33	6.93	7.77	10.74	5.27	6.47	4.43	5.92	5.92	4.43	3.45	7.61	6.22	11.04	9.25	5.26	9.00	8.87	7.14	8.16	6.98	9.23	6.22	5.27
31	10.51	7.40	8.78	6.88	7.18	6.31	7.76	7.73	8.47	9.20	7.81	8.73	8.82	8.34	10.81	10.81	8.59	7.57	6.99	8.10	6.70	11.87	8.23	8.46	4.13	7.05	7.05	8.46	6.80	7.23	6.22	10.15	8.11	4.20	9.08	8.10	10.80	7.83	6.98	8.06	7.94	8.23
41	9.20	5.57	9.30	7.79	3.90	7.83	8.52	8.02	8.05	9.96	8.92	7.01	10.03	7.84	11.03	11.03	10.20	8.35	9.45	8.33	6.32	10.78	7.41	8.46	4.80	6.68	6.68	7.84	4.39	8.37	6.22	9.99	8.36	7.58	9.42	8.47	7.96	8.28	5.57	7.75	7.27	7.41
42	7.85	7.57	8.33	7.54	6.60	7.62	6.29	7.17	8.22	9.10	9.77	8.21	5.38	8.17	11.04	11.04	10.08	5.16	7.56	7.61	7.27	11.35	6.56	8.74	5.04	5.67	5.67	5.20	10.15	7.39	6.11	12.20	8.01	5.77	8.61	7.87	9.40	7.17	5.98	7.31	6.89	6.56
43	7.85	7.57	8.33	7.54	6.60	7.62	6.29	7.17	8.22	9.10	9.77	8.21	5.38	8.17	11.04	11.04	10.08	5.16	7.56	7.61	7.27	11.35	6.56	8.74	5.04	5.67	5.67	5.20	10.15	7.39	6.11	12.20	8.01	5.77	8.61	7.87	9.40	7.17	5.98	7.31	6.89	6.56
mean for mandible	8.71	7.19	8.64	7.01	6.19	7.34	7.09	7.75	8.38	10.06	8.37	8.15	7.26	8.11	10.67	10.67	9.52	6.99	7.78	8.17	7.25	11.54	7.03	8.27	4.63	6.21	6.21	6.49	6.18	7.74	6.24	11.37	8.58	5.95	9.08	8.36	8.66	7.93	6.21	8.08	7.31	7.03

POST Clinical Crown Height value

sl no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
13	8.29	9.56	8.33	8.29	8.65	8.55	7.81	8.07	6.41	11.97	9.21	7.47	9.02	6.94	10.72	10.72	12.96	8.46	9.67	8.58	9.37	12.96	8.40	7.47	9.59	7.68	7.68	5.64	9.31	8.32	6.93	9.96	7.36	14.90	8.94	9.30	9.75	7.47	5.87	6.03	7.59	9.37
12	7.62	8.51	8.86	7.62	8.62	7.62	8.34	8.22	7.75	9.67	9.86	6.10	7.49	6.52	9.56	9.56	9.69	8.01	8.81	7.81	9.96	9.69	6.98	9.31	9.27	7.56	7.56	5.07	8.28	6.89	7.30	10.81	6.94	13.17	7.47	10.29	9.80	8.11	6.35	6.30	7.84	9.96
11	10.95	9.81	9.45	10.95	9.71	10.17	10.31	10.57	9.07	10.73	10.62	7.59	10.75	8.13	12.88	12.88	12.96	9.11	11.21	9.91	11.56	12.96	9.89	10.39	11.43	9.20	9.20	7.17	10.01	8.85	8.18	13.68	9.11	16.84	9.87	10.60	11.98	10.30	8.27	8.71	9.23	11.56
21	11.43	9.56	8.95	11.43	10.25	9.69	10.59	11.07	9.35	12.26	11.88	7.31	10.08	8.03	13.00	13.00	12.85	8.78	10.35	10.48	12.29	12.85	10.39	6.71	11.21	9.45	9.45	6.50	10.97	6.78	9.20	13.86	8.46	15.52	9.77	10.80	11.81	9.75	8.18	8.20	8.72	12.29
22	7.24	8.06	8.20	7.24	8.62	7.91	8.25	7.36	8.22	11.59	10.33	6.10	7.39	5.95	8.55	8.55	10.35	7.35	8.91	8.38	10.13	10.35	7.48	8.77	8.84	7.31	7.31	5.16	7.85	6.67	7.73	11.16	8.17	11.38	8.33	10.64	10.09	7.01	6.98	6.78	7.84	10.13
23	7.44	9.39	8.29	7.44	8.97	8.42	8.29	8.36	7.84	9.82	9.21	6.53	8.93	6.15	9.82	9.82	11.87	8.12	8.81	11.48	11.08	11.87	8.32	9.96	10.24	7.18	7.18	5.17	8.75	7.65	7.13	8.70	6.98	13.45	9.29	10.73	9.48	7.13	6.26	5.02	8.47	11.08
mean of maxilla	8.83	9.15	8.68	8.83	9.14	8.73	8.93	8.94	8.11	11.01	10.19	6.85	8.94	6.95	10.76	10.76	11.78	8.31	9.63	9.44	10.73	11.78	8.58	8.77	10.10	8.06	8.06	5.79	9.20	7.53	7.74	11.36	7.84	14.21	8.95	10.39	10.48	8.29	6.98	6.84	8.28	10.73
33	7.52	9.56	8.45	7.52	8.40	6.14	9.65	9.07	6.73	14.09	8.19	5.54	11.42	5.76	11.10	11.10	14.59	8.37	7.76	10.00	9.83	14.59	7.90	8.01	8.19	7.56	7.56	5.84	10.23	8.05	10.27	13.28	8.57	13.46	10.44	8.41	9.86	7.23	6.47	6.88	7.22	9.83
32	8.69	5.74	6.77	8.69	7.64	5.84	7.41	9.29	7.75	13.07	8.92	5.75	9.57	5.67	10.58	10.58	11.76	6.15	7.86	7.24	8.92	11.76	6.90	8.12	7.22	6.68	6.68	5.35	7.49	7.54	8.07	11.99	7.29	11.91	8.24	7.77	8.33	5.15	6.54	7.29	6.32	8.92
31	7.36	8.06	6.44	7.36	8.18	5.57	8.06	8.50	8.31	10.21	6.51	6.03	10.48	7.18	9.82	9.82	11.89	6.80	8.53	7.91	7.64	11.89	6.90	9.20	6.25	6.93	6.93	6.36	9.33	6.37	7.31	11.99	7.49	11.80	8.62	7.77	12.33	6.30	7.02	6.20	8.73	7.64
41	9.55	8.40	8.28	9.55	7.00	5.74	10.03	8.22	8.22	11.11	8.27	6.17	11.61	6.33	10.20	10.20	15.03	6.70	9.10	8.78	7.48	15.03	7.65	8.34	7.17	7.68	7.68	5.44	9.65	8.20	7.12	13.52	6.62	15.73	8.62	7.39	13.48	5.38	6.55	6.78	9.77	7.48
42	9.35	6.90	6.52	9.35	6.66	7.28	7.50	9.29	7.75	10.67	4.98	6.81	9.79	5.95	11.18	11.18	13.31	6.47	8.33	8.54	8.52	13.31	7.15	8.98	7.24	8.19	8.19	4.97	9.36	6.23	7.78	13.51	6.19	13.55	8.33	7.80	9.05	5.59	6.90	7.32	7.21	8.52
43	10.11	7.81	9.12	10.11	7.31	7.34	6.37	10.07	8.03	10.48	6.78	7.38	14.23	6.05	12.43	12.43	11.14	7.36	8.81	10.69	10.09	11.14	6.76	8.98	7.14	7.44	7.44	6.22	12.80	8.31	10.34	12.33	7.70	13.24	9.20	10.58	11.34	8.98	7.14	6.95	6.58	10.09
mean of mandible	8.77	7.75	7.60	8.77	7.53	6.32	8.17	9.07	7.80	11.61	7.28	6.28	11.19	6.16	10.89	10.89	12.96	6.97	8.40	8.86	8.75	12.96	7.21	8.61	7.20	7.41	7.41	5.70	9.81	7.45	8.48	12.77	7.31	13.28	8.91	8.29	10.73	6.44	6.77	6.90	7.64	8.75

Pre orthodontic treatment values keratinized tissue (in mm)

sl no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
13	4.85	4.12	4.00	4.85	3.40	3.35	3.47	3.92	2.21	3.47	3.31	4.37	3.69	2.30	3.35	4.11	4.86	3.60	4.98	4.19	5.21	4.98	3.39	4.83	3.81	3.09	3.93	3.25	3.48	3.39	4.83	3.81	3.09	3.93	4.19	5.21	4.98	3.39	4.83	3.81	3.09	3.93
12	5.79	4.11	4.16	5.79	4.30	2.85	3.09	3.43	3.33	3.09	3.39	5.42	3.77	3.45	3.59	4.59	5.59	3.51	4.47	4.30	4.97	4.98	1.93	5.68	3.40	3.26	2.76	4.11	3.20	1.93	5.68	3.40	3.26	2.76	4.30	4.97	4.98	1.93	5.68	3.40	3.26	2.76
11	4.46	3.50	3.34	4.46	4.12	3.42	2.93	3.96	3.93	2.93	3.64	4.27	3.24	2.79	4.00	4.68	5.74	3.51	3.96	4.52	4.97	4.02	4.14	3.98	3.48	2.68	2.43	4.40	2.82	4.14	3.98	3.48	2.68	2.43	4.52	4.97	4.02	4.14	3.98	3.48	2.68	2.43
21	4.22	3.49	2.94	4.22	3.98	3.75	2.42	3.95	2.93	2.42	3.64	4.58	3.37	3.29	4.00	5.74	4.42	3.42	3.83	5.18	5.21	4.60	3.08	3.50	3.64	2.51	2.84	4.88	2.82	3.08	3.50	3.64	2.51	2.84	5.18	5.21	4.60	3.08	3.50	3.64	2.51	2.84
22	4.95	3.01	3.61	4.95	3.92	3.42	2.57	3.61	2.60	2.57	3.47	4.68	2.59	3.70	3.10	4.21	5.00	3.13	4.22	4.30	5.33	4.89	3.08	4.73	4.14	2.93	2.51	4.88	2.82	3.08	4.73	4.14	2.93	2.51	4.30	5.33	4.89	3.08	4.73	4.14	2.93	2.51
23	3.74	4.11	3.18	3.74	3.17	3.43	2.97	3.29	3.32	2.97	3.39	4.58	2.40	3.04	3.51	4.49	4.56	3.13	4.60	4.85	5.21	4.12	2.51	4.36	3.56	2.59	3.51	3.25	2.26	2.51	4.36	3.56	2.59	3.51	4.85	5.21	4.12	2.51	4.36	3.56	2.59	3.51
33	4.57	2.38	2.47	4.57	4.10	2.84	2.42	2.52	2.75	2.42	3.72	4.68	2.40	1.31	3.43	3.16	2.80	2.28	3.19	3.19	3.43	2.39	3.18	2.46	3.48	1.67	3.01	3.35	3.01	3.18	2.46	3.48	1.67	3.01	3.18	3.43	2.39	3.18	2.46	3.48	1.67	3.01
32	2.97	2.11	1.56	2.97	3.01	3.49	2.62	2.20	2.28	2.62	4.13	3.85	3.24	1.97	4.17	3.06	3.24	2.85	3.70	3.97	3.79	4.60	3.57	3.22	4.22	2.26	2.43	2.87	2.54	3.57	3.22	4.22	2.26	2.43	3.97	3.79	4.60	3.57	3.22	4.22	2.26	2.43
31	3.09	1.37	2.45	3.09	3.17	2.52	1.71	1.94	2.24	1.71	3.29	3.54	2.59	2.30	3.27	3.25	2.06	2.37	3.83	4.85	4.26	3.07	3.47	1.42	2.57	1.17	2.17	2.10	2.26	3.47	1.42	2.57	1.17	2.17	4.85	4.26	3.07	3.47	1.42	2.57	1.17	2.17
41	3.22	2.01	3.04	3.22	3.01	2.39	2.27	1.94	1.90	2.27	3.14	3.43	2.53	1.81	2.61	2.77	3.38	2.66	3.96	3.41	4.97	4.41	3.08	1.23	3.06	1.25	2.43	2.20	2.07	3.08	1.23	3.06	1.25	2.43	3.41	4.97	4.41	3.08	1.23	3.06	1.25	2.43
42	2.61	1.87	3.30	2.61	2.64	3.36	2.37	2.01	2.36	2.37	3.88	2.91	3.31	1.97	2.94	2.68	2.65	2.66	3.70	3.86	3.55	3.64	1.83	3.50	3.06	2.17	2.34	2.87	2.54	1.83	3.50	3.06	2.17	2.34	3.86	3.55	3.64	1.83	3.50	3.06	2.17	2.34
43	3.23	2.54	2.13	3.23	2.99	2.59	2.32	2.07	2.41	2.32	4.05	3.54	2.66	1.81	2.61	2.58	2.65	2.37	3.83	3.86	3.55	2.30	1.64	1.99	1.90	1.76	2.43	3.35	2.16	1.64	1.99	1.90	1.76	2.43	3.86	3.55	2.30	1.64	1.99	1.90	1.76	2.43

Post orthodontic treatment values keratinized tissue (in mm)

sl no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
13	4.41	3.39	3.28	4.41	3.59	5.84	3.25	3.57	3.29	3.52	3.36	2.83	3.06	2.83	3.81	4.86	5.26	4.46	5.00	4.43	5.52	4.19	2.93	4.03	5.71	2.99	3.75	3.54	4.33	4.43	5.52	4.19	2.93	4.03	3.39	3.28	4.41	3.59	5.84	4.03	5.71	2.99
12	2.69	3.15	3.87	2.69	4.31	3.76	3.72	2.53	4.05	4.07	4.73	3.58	2.54	3.58	4.89	5.59	6.26	3.32	4.66	4.15	4.29	4.63	2.76	4.25	4.67	2.89	3.75	3.06	3.67	4.15	4.29	4.63	2.76	4.25	3.15	3.87	2.69	4.31	3.76	4.25	4.67	2.89
11	3.33	3.53	4.27	3.33	3.69	3.48	2.89	2.47	4.29	3.44	4.73	4.00	3.50	4.00	4.22	5.74	6.26	3.60	4.66	3.58	4.54	4.08	1.93	4.14	4.86	2.69	3.27	3.44	3.29	3.58	4.54	4.08	1.93	4.14	3.53	4.27	3.33	3.69	3.48	4.14	4.86	2.69
21	3.33	4.66	3.03	3.33	3.97	3.26	2.85	2.38	4.21	2.31	3.98	3.42	3.28	3.42	3.73	4.42	5.51	3.42	4.66	5.28	5.15	4.30	2.26	4.14	3.33	3.17	4.23	3.54	3.11	5.28	5.15	4.30	2.26	4.14	4.66	3.03	3.33	3.97	3.26	4.14	3.33	3.17
22	3.88	3.66	4.07	3.88	3.25	3.09	3.54	2.46	3.90	3.52	4.23	3.17	2.83	3.17	3.64	5.00	5.51	3.51	4.66	4.53	5.03	4.30	2.35	4.25	3.33	2.60	3.65	3.25	2.92	4.53	5.03	4.30	2.35	4.25	3.66	4.07	3.88	3.25	3.09	4.25	3.33	2.60
23	3.54	3.82	3.40	3.54	3.39	3.82	4.18	3.12	3.53	3.74	3.24	3.25	3.06	3.25	3.73	4.56	4.76	4.36	5.44	4.62	5.27	3.75	2.18	3.70	4.48	2.21	4.33	3.06	4.61	4.62	5.27	3.75	2.18	3.70	3.82	3.40	3.54	3.39	3.82	3.70	4.48	2.21
33	3.76	2.89	2.63	3.76	4.24	2.08	3.25	3.57	3.53	3.74	4.11	3.50	2.46	3.50	3.06	2.80	4.13	5.03	3.11	3.58	3.68	2.20	2.93	3.05	2.76	2.21	3.65	1.82	2.73	3.58	3.68	2.20	2.93	3.05	2.89	2.63	3.76	4.24	2.08	3.05	2.76	2.21
32	4.08	3.52	1.88	4.08	2.96	2.25	3.73	4.09	3.37	3.19	4.23	2.92	3.88	2.92	2.90	3.24	4.27	3.78	3.96	4.17	3.86	2.18	4.03	4.29	2.99	2.60	2.68	2.45	3.96	4.17	3.86	2.18	4.03	3.52	1.88	4.08	2.96	2.25	4.03	4.29	2.99	
31	4.19	2.14	1.88	4.19	2.82	1.97	3.35	3.64	2.78	2.97	4.11	2.33	3.50	2.33	4.14	2.06	4.26	4.27	3.89	3.39	3.19	2.42	2.10	1.75	3.24	1.73	2.69	1.91	1.51	3.39	3.19	2.42	2.10	1.75	2.14	1.88	4.19	2.82	1.97	1.75	3.24	1.73
41	4.30	2.89	2.08	4.30	3.67	2.14	2.90	3.81	3.17	3.52	4.36	1.34	3.43	1.34	3.40	3.38	4.01	3.89	3.22	3.77	3.19	2.97	2.35	4.36	3.81	1.92	2.98	1.82	2.07	3.77	3.19	2.97	2.35	4.36	2.89	2.08	4.30	3.67	2.14	4.36	3.81	1.92
42	3.90	3.08	2.93	3.90	2.54	2.25	2.50	3.28	2.54	2.86	4.36	2.67	3.88	2.67	2.98	2.65	3.51	3.70	2.78	3.96	3.56	3.30	2.26	3.38	4.57	2.21	2.69	2.68	2.92	3.96	3.56	3.30	2.26	3.38	3.08	2.93	3.90	2.54	2.25	3.38	4.57	2.21
43	3.35	2.81	2.63	3.35	3.46	1.40	2.92	3.19	3.29	3.08	3.24	2.42	3.95	2.42	3.48	2.65	4.13	4.08	3.67	3.39	3.56	2.75	2.35	3.27	3.05	2.60	3.08	2.87	2.73	3.39	3.56	2.75	2.35	3.27	2.81	2.63	3.35	3.46	1.40	3.27	3.05	2.60