AN IN VIVO EVALUATION OF THE RELATIONSHIP BETWEEN WALA RIDGE AND MANDIBULAR TEETH IN SKELETAL CLASS I PATTERN

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LIST OF ABBREVIATIONS

Serial no.	Abbreviations	Full form
1.	**WALA**	Will Andrews, Larry Andrews
2.	**CRes**	Centre of Resistance
3.	**AL**	Alveolar mucosa
4.	**KT**	Keratinized tissue
5.	**MGJ**	Mucogingival junction
6.	**CuNiTi**	Copper Nickel Titanium
7.	**FA**	Facial Axis
8.	**FACC**	Facial Axis of Clinical Crown
9.	**WH**	WALA Horizontal
10.	**WV**	WALA Vertical
11.	**BA**	Buccal axis point
12.	**DWALA**	Difference between actual & normal WALA Horizontal
13.	**UIMW**	Upper inter-molar width
14.	**LIMW**	Lower inter-molar width
15.	**UICW**	Upper inter-canine width
16.	**LICW**	Lower inter-canine width
17.	**Fig**	Figure
18.	**Etc**	Et cetera
19.	**i.e.,**	That is
20.	**mm**	Millimetre
21.	**Class II div 1**	Class II division 1
22.	**CT**	Computed Tomography
23.	**CBCT**	Cone beam Computed Tomography

24.	**3D**	Three-dimensional
25.	**SARME**	Surgically aided rapid maxillary expansion
26.	**PA**	Posteroanterior
27.	**2D**	Two-dimensional
28.	**%**	Percent
29.	**AW**	arch width parameters
30.	**ABO**	American Board of Orthodontics

INTRODUCTION

Appraisal of Orofacial complex and maintenance of its harmony holds utmost importance. Orthodontists should take care not to abuse the gingival tissues, roots and bone even if these aren't treated by them directly.[1]

The assessment of anatomy, ensures the distinguished task of the occlusion, periodontal health, coveted aesthetics, and stability of the dental archform. Hence, the orofacial harmony is to be perpetuated throughout and post-treatment.[2]

It has been documented by Weaver et al[3] that pre-formed archwires are used more than the customized archwires, which most of the time are not pertaining to the original archform of the patient. So, despite of the successful correction of any malocclusion, resultant occlusion can remain unstable and relapse can occur. Or sometimes, periodontium is hampered which results into dehiscence and fenestrations. There shall be environs of equilibrium between the muscles of mastication, TMJ and dentition as it is equally crucial to engender safe and stable results to the patients. This can be ensured by good knowledge of stomatognathic anatomical structures.[3,14]

Andrews[4] gave '6 keys to normal occlusion' which were gold standard for establishing occlusion. Eventually, he introduced "6 Elements of Orthodontic Philosophy" wherein the Element I elucidated the optimal arch positions: roots centred on basal bone, crowns sloped so that there is exquisite intercuspation and function, 'Curve of Spee' 0- 2.5 mm, contact areas adjoin & skeletal maxillary transverse dimensions corresponds to that of mandibular width.[5,9]

He also introduced "WALA ridge", a landmark which aids to establish the right arch form heading towards the utmost ideal dental location in the mandible relative to the basal bony area. This terminology was coined by the father-son duo- 'Will Andrews & Larry Andrews' who referred it as "the most eminent part of mandible's muco-gingival junction, which is situated at or just near the centre of rotation of teeth". This landmark assist in determining the right arch form, which leads to the utmost tooth location in the mandible in relation to the apical base.[5,9]

Apt tooth location in all the three planes while maintaining the limits of the bone, which is underlying, is an important emblem to provide a base of solidity for the dentition and the periodontium.[5]

Despite of this ideal teeth position has been scrutinized over many years, Orthodontists are even now divided to form extraction vs non- extraction dicta. Here we come across two school of thoughts. First, being the 'bone growing theory' of Edward Angle[6] based upon the crowding cases he treated by expansion in order to fit in all teeth. As per the study, normal stimulation and environmental forces (like mastication, pressure from tongue/cheeks) are responsible for the alveolar bone growth, if teeth are optimally arranged. This was authenticated by 'Wolf's Law' by J. Wolf who said that bone will adapt to the load applied, in a healthy individual. If loading increase, the bone will remodel to develop sturdier i.e., cortical plate becomes bulky and vice versa. Therefore, this theory collectively was referred as 'the non-extraction theory'. [3,6]

Second, Lundstrom[7] in 1925 postulated that the 'apical base' controlled the inception of standard occlusion rather than changing itself to fit the normal occlusion (genetically controlled). 3 tenets were proposed: 1) after tooth loss, apical base remains unchanged, 2) unaffected by Orthodontic tooth movement, 3) apical base restricts the area of dental arch.

According to this theory, if teeth are displaced far off the apical base, there will be resultant buccal tipping[7], periodontal ill- effects[8] and unsteady treatment.[10]

After observing the wobbly results, the disciples of Angle re-examined the study models and one of them viz. Tweed[10] reinforced the extraction mechanics in 1930's. Begg[11] also incorporated extractions pertaining to the modern soft diet.

The 'apical base theory' was widely accepted until 'bone growing theory's' reiteration was done by Damon prescription (2005). It's claimed that it works on the principle of passive expansion as bone is laid in response to the forces.[12]

Despite of more inclination towards the non-extraction theory, there always lie anatomical constraints for expansion and space gaining. This gave birth to the

WALA ridge concept which enables us locate the apical base and the ideal shape of the arch.[5]

Andrews hypothecated tipping the teeth with respect to their Cres, to an erect position (expansion of the arches) concentrated within basal bone resulted, when archwires are contoured along the WALA ridge.[3] However, it is uncertain whether it can be extrapolated to the Indian population or not as the previous studies were based on Caucasian population.

It was needful to undertake a study to delineate the basal bone and eventually the WALA ridge so as to get a clinical picture for better treatment planning as we pre-determine the physiological border of Orthodontic tooth movement.

As the alveolar mucosa (AL) has elevated amount of glycogen as compared to the keratinized tissue (KT); AL gives iodo-positive reaction whereas KT gives iodo-negative reaction when the gingival tissue is stained by Lugol’s solution. Hence, we get a sharp demarcation at the mucogingival junction, just superior to which lies the WALA ridge.[13]

The study attempts to investigate the association of the dental archform with the mandibular teeth, especially in Indian population, using WALA ridge as a marker. WALA ridge being a soft tissue landmark, can be best possibly assessed intra-orally rather than simulating the structural anatomy in the form of dental casts. Thus, an in vivo study is undertaken.

AIM AND OBJECTIVES

AIM -

The present study aimed to evaluate the relationship between the WALA ridge and the mandibular posterior teeth in patients belonging to Skeletal Class I pattern, in Central India Population.

OBJECTIVES -

- To appraise the WALA ridge intra-orally.
- To assess the relationship between the WALA ridge and mandibular teeth.

REVIEW OF LITERATURE

The review of literature constitutes the following:

- Relationship of dental arch and basal bone
- 6 Elements of Orthodontic philosophy
- In-vivo appraisal methods of WALA ridge demarcation

Riedel (1917)[15] developed SNA and SNB as angular measurements, from A and B points of Down's analysis, to check the basal bone relationships sagittaly. It does not quantify the size of apical base but it locates the anterior restraints of the apical bases.

Howes (1919)[16] found the apical base 8 mm below the marginal gingiva and in the apical 1/3rd of the alveolar bony region in the lower arch.

Rees (1920)[17] used plaster models to locate the basal one 8 – 10 mm apical to marginal gingiva.

Downs (1923)[18] gave points A & B, to represent both of the dentures bases in the "Down's Cephalometric analysis".

Axel F. Lundstrom (1925)[7] stated malocclusion id generally rooted to the abnormalities in the basal bone and have to be corrected accordingly.

Izard (1927)[19] showed anthropology is crucial in determining the optimal arch. He also enlisted why previous studies failed to do so.

Turner (1932)[20] studied about the movements of teeth in the jaws, as revealed after extractions- the movements other than the ones which are concomitant with the growth of maxillary or mandibular arch as they move forward. (2) Movements due to forces external to the bone which are resultant of early extractions. (3) The association of deformity with adenoids- there is failure of growth of maxilla and lateral compression.

Brodie (1938)[21] introduced usage of cephalometer as a cephalometric appraisal method of Orthodontic results, before which they categorised patients arbitrarily according to Angle's malocclusion.

Tweed (**1944**)[22] researches on situating the mandibular incisors erect over the apical bases to ensure better stability and defined apical base as "to produce stable Orthodontic outcomes, the lower central incisors must be placed over the bony ridge".

Salzmann (**1948**)[23] reworked on the definition using lateral cephalogram to study the mandibular region which begins at the most constricted point on the body of the mandible and referred it to basal bone.

Brodie (**1950**)[24] said, the scarcity of attainable techniques was the antecedent for this paucity of depiction of the basal bone.

Howe (**1954**) [25] There are variations of tooth morphology, arch widths, and basal arch length. When same kind of mensuration of malocclusion are plotted on graphs, the digressions from the usual can be seen. These graphs are useful to compare the cephalometric profile tracing with normal digressions, to alleviate ambiguity regarding dentofacial complex, and to manifest that is already accomplished with treatment. Furthermore, in case study, the information gathered from graphs, adjoined with all other information, benefits in treatment planning.

Frankel (**1960**)[26] suggested that to increase the alveolar bone growth, fluctuation of eruption pattern could be used by incorporating vestibular shields. The Frankel function regulator appliance was utilized to override the attachment of the cheeks and lips at the sulcus resulting in more development of the basal bone.

Falck (**1962**)[27] defined the apical base as the region resulting from the periphery of inter-relation of both the credential points situated 14mm from buccal cusps of the primary first molars/premolars.

Baldridge (1969)[28] concluded that it was overestimated that 1 mm of arch circumference was necessary to level 1mm COS.

Miethke et al. (**1970**)[29] argued that Falck's method of locating the apical base was inaccurate for comparing treatment outcomes. The difference in the crown heights between these two tooth types would change reference points and thus change the apical base level

Miethke (1972)[29] used gingival margins as a reference point similar to Howes and Rees. He studied the effects of Frankel's functional regulator on apical base dimensions.

Musich & Ackerman (1973)[30] found out "Catenometer" to measure the dental arch perimeter by hanging catenary method against the conventional method which make use of the Brass wire.

Miethke et al. (1974)[31] defined the apical base as the peripheral connection of six referenced landmarks 5mm below the most apical points of the gingival margins of the lower lateral incisors, canines, and second primary molars or premolars.

Sergl, Kerr, and McColl (1980)[32] used the most concave contour of the buccal surface of the casts to measure the basal bone area.

Kanaan (1981)[33] measured basal bone perimeters from traditionally available orthodontic records including dental plaster casts and cephalogram. The posterior limit of basal bone was defined as being perpendicular to the functional occlusal plane mesial to the first molars.

Bell (1985)[34] used cone beam computerized tomography in his study to demonstrate that basal bone at the level of B point was very similar to basal bone at a level below the root tips demonstrating that it is not necessary to consider bone lower than B point in order to have continuous CBCT slices back to the second molars.

Felton et al (1987)[35] To determine whether a particular ideal orthodontic arch form could be identified, the mandibular dental casts of 30 untreated normal cases, 30 Class I non-extraction cases, and 30 Class II nonextraction cases were examined. Following computerized digitizing and the use of a mathematic function called polynomial of the fourth degree, arch forms were generated for each sample and then compared to 17 commercially produced arch forms. Results showed that no particular arch form predominated in any of the three samples. A shape representing a combination of the "Par" and "Vari-Simplex" arch forms approximated to only 50% of the cases in the three samples. The remaining 50% of the cases displayed a wide variety of arch forms. Cases that had changes in arch form during nonextraction treatment frequently were not stable; almost 70% showed significant long-term posttreatment changes. Customizing arch forms appears to be necessary in many cases to obtain optimum long-term stability because of the great individual variability in arch form found in this study.

McReynolds & Little (1991)[36] The dental casts and cephalometric radiographs of 46 patients, treated with mandibular second premolar extraction and edgewise orthodontic mechanotherapy, were evaluated for changes over a minimum 10-year postretention period. The sample was divided into two groups: early (mixed dentition) extraction of mandibular second premolars and late (permanent dentition) extraction of mandibular second premolars. Results showed no difference in long-term stability between the two groups. Arch length and arch width decreased with time and incisor irregularity increased throughout the postretention period. No predictors or associations could be found to help the clinician in determining the long-term prognosis in terms of stability. The sample was regrouped according to the postretention degree of incisor irregularity. Statistically significant differences in cephalometric measurements were found between the minimally crowded group and the moderately to severely crowded group.

Germane et al (1992)[37] Arch length analysis should consider discrepancies not only within the sagittal plane but also within the vertical and transverse planes. The vertical deviation of the occlusal plane from a flat plane is known as the curve of Spee. The purpose of this study was to produce a mathematical model of the mandibular arch form in three planes of space and to determine the effect that the curve of Spee has on arch circumference. Two mandibular arch forms, the catenary and the Bonwill-Hawley, were examined. The curve of Spee was modeled as a cylinder perpendicular to the midsagittal plane centered on the arch anteroposteriorly. A mathematical distance formula was used to calculate arch circumferences from the central fossa of the first molars for 10 arches with curves of Spee ranging from 0 to 10 mm. This procedure was repeated for arch circumferences extending from the central fossa of the second molars. Plots for the difference in arch circumferences verses depth of the curve of Spee showed that the relationship between these two variables is not linear and is less than one to one. This model showed that clinical practice of allowing 1 mm of arch circumference for leveling each mm of curve of Spee overestimates the amount of arch circumference needed to flatten the curve of Spee.

Ladner & Muhl (1995)[38] A retrospective study of dental and maxillary skeletal changes occurring during a period of orthodontic treatment was made from pretreatment and posttreatment dental casts. Sixty maxillary expansion cases were examined. Thirty cases had maxillary expansion accomplished with a fixed rapid palatal expander and 30 were expanded with a quadhelix appliance. All cases were finished with full fixed edgewise appliances. Multiple linear regression analyses were completed for both groups with upper molar width change as the criterion and age, tipping of the upper molars, palatal width change and maxillary tipping as the predictors. All predictors were included in the analysis for the quadhelix group. The other variables did not meet the level of significance for entry into the model. Although both groups demonstrated similar amounts of maxillary dental expansion, the rapid expansion group demonstrated greater average skeletal expansion. In addition, there was a significant relationship between skeletal and dental expansion for the rapid expansion group, but not the quadhelix group. Palatal depth increased more on average in the rapid expansion group suggesting that there was greater dental eruption in that group. Expansion across the mandibular molars was greater on average in the quadhelix group. There was no difference in the degree of upper molar rotation or final upper and lower arch forms between the two groups.

Burke et al (1998)[39] The meta-analysis technique of literature review was applied to a total of 26 previous studies to assess the longitudinal stability of postretention mandibular intercanine width. Weighted averages and standard deviations for the means of 1,233 subjects were compared for linear changes in intercanine transverse dimensions during treatment (T1), immediately after treatment (T2), and after removal of all retention (T3). Net change was defined as the difference between means at T3 and T1. Dimensional changes were also evaluated on the basis of patient pretreatment Angle classification, extraction, and nonextraction treatment modalities of each group. Statistically significant differences were observed for the following groups: all patients; nonextraction;

extraction; Class I; Class I extraction; Class II extraction; and, Class I Division 1 nonextraction. The findings of this study indicate that regardless of patient diagnostic and treatment modalities, mandibular intercanine width tends to expand during treatment on the order of one to two millimeters, and to contract postretention to approximately the original dimension. While statistically significant differences could be demonstrated within various groups, the magnitudes of the differences were not considered clinically important.

Corruccini RS(1999)[40] elicited how anthropology informs the orthodontic diagnosis of malocclusion's causes.

L.F.Andrews (2000)[9] gave the concept of "6-elements of Orthodontic Philosophy" for which orthodontists have diagnostic and treatment responsibilities. The elements aided as the treatment targets for the six areas of the orofacial complex viz.: **a)** Arches: individual teeth positions, morphology and quantity; and overall arch width, length, depth, shape and symmetry); **b)** Sagittal jaw positions, **c)** Jaw widths, **d)** Jaw heights, **e)** Chin elevation **f)** Occlusion.

Gugleilmoni et al (2001)[41] broadly classified the demarcation methods for mucogingival junction as: a) 'Visual method' where MGJ was evaluated as a scalloping strip separating alveolar mucosa from gingival mucosa ;b) 'Functional Method'- a periodontal probe was stroked parallelly on the vestibule toward gingival margin to determine the mobility of the border between movable and immovable mucosa ;c) 'Visual method after Histochemical staining': MGJ was stained by Lugol's solution; based on the fact that AL gives 'iodo-positive reaction' whereas KT gives 'iodo-negative reaction.' They concluded that the inter and intra examiner reproducibility was substantially consistent by determining MGJ by various methods.

Strang (2002) [42] believed that for treatment of malocclusion, dentoalveolar expansion should be rejected as a treatment procedure and muscular balance should be ensured.

Wonglamsam (2003) [43] Importance is attached to assessment of anterior facio-lingual maxillary and mandibular apical base widths in determining limits to incisor root movements. There is absence of similar assessment of faciolingual base widths for premolars and molars. The aims of this paper are two-fold: to determine the strength of associations between the faciolingual widths of the anterior and buccal alveolar apical bases, and to determine if an association might exist between the posterior alveolar base width and specific lateral cephalometric measurements. Comparative measurements were made on 40 adult Thai skulls and their companion mandibles using lateral cephalometric radiographs, linear tomography, and direct measurements of the dentoalveolar and basal structures. Wide variation was found in faciolingual widths of the alveolar bases. No significant correlations were found between the faciolingual widths of the anterior and posterior alveolar bases in the maxillae and mandible. Significant inverse correlations were found between the alveolar base widths at the mandibular incisors and the angles, and between maxillary incisor base widths and the gonial angle. Importantly, no cephalometric indicators were found to predict posterior alveolar base widths. There is a need to continue to search for assessment indicators.

Vanarsdall et al (2004) [44] confirmed that basal bone anatomy remains unaffected by the standard edgewise orthodontic treatment.

Mommaerts (2004) [45] A narrow anterior apical base in both jaws can cause pronounced crowding, which can be corrected by extraction therapy (as a rule extraction of four premolars) or by transverse distraction osteogenesis therapy (as a rule bimaxillary), followed by orthodontic treatment. A case is reported of bimaxillary transverse distraction osteogenesis in an eleven-year-old female patient. Alignment was performed with fixed orthodontic appliances. Correction of the skeletal Class II relationship was done with a functional appliance. The active treatment time was eighteen months.

Damon (2005)[12] developed his philosophy of using flexible CuNiTi to dissipate expansile forces much lesser exerted than wires of Gold, German silver, or chrome steel. Orthodontic philosophy was dominated by "apical base theory" for many years, until the Damon appliance reiterated the bone growing theory.

Ronay et al (2008)[1] laser scanned 35 mandibular dental arches at bonding points of the bracket and the morphology of basal bone for determination of the apical base whether a standardized archform could be derived or not. A 3D model was obtained. FA and WALA points were studied and compared from molar to molar. Inter-canine and inter- molar distances were measured. In the results, it was found that both archforms were very discrete. FA & WALA points are highly correlated and study concluded that both the point-obtained arch forms were unique and could not be stereotyped in shape. The basal bone was effectively depicted by WALA points and it aided in the foreknowledge of a unique dental archform.

McNamara et al (2009)[46] During the preliminary and later phases of orthodontic therapy with fixed appliances, physicians made decisions about archwires and arch shape which was studied by McNamara. The former section of the questionnaire contended with the leveling and alignment and the latter dealt with the space-closure stage of treatment in cases where premolars were extracted. At both stages, the importance of archwire selection, intra-arch dimensions and relevance of arch shape were evaluated. The practitioners were also quizzed on their regular procedures for adapting working archwires and using study models and centrosymmetric charts. Most of clinicians believed that preserving the original arch form as well as the inter-canine width was crucial in the later stages of treatment. There was, however, no consensus on how to preserve arch form. Dental casts and symmetry charts were utilized by some respondents as aids, but they were employed in a variety of ways. When fitting stainless steel archwires to arch shape, there was no homogeneity in the landmarks employed. Even if the clinicians customized the archforms, there was no template for doing so. Also, the reproducibility was not up to the mark.

Trivino, Siqueira, Andrews (2010)[47] In Brazilians with normal occlusion, the distance between the lower permanent teeth and the alveolar bone were measured and compared to typical American values. 59 mandibular models with permanent dentition and the six keys to proper occlusion were used. The distances between the incisors and molars increased gradually from 0.00 to 2.49 mm. Except for the values for canines and first premolars, all data were statistically significant when compared to the American group. Brazilians with normal occlusion had higher lingual crown placements for incisors, second premolars, and molars.

Ball (2010)[48] Patients with Class I malocclusion had their mandibular dental arch form and mandibular basal bone arch form compared to those with Class II Division 1 malocclusion. The goal of this study was to see if there were any variations in dental and basal transverse measurements and arch forms between the two groups, as well as to see if WALA points could be used to predict a stable dental arch form in Class II Division 1 individuals. A laser scanning device was used to construct three-dimensional graphic representations of mandibular casts from 35 Class I malocclusion patients and 32 Class II Division 1 patients. To depict the dental arch form (FA points) and the arch form of the basal bone, anatomic reference points were subjectively determined and employed (WALA points). The FA point intercanine width in the Class II Division 1 data was substantially bigger than in the Class I sample, although the basal arch shape, denoted by the WALA ridge, wasn't substantially different. The FA points for intermolar width and the arch form of the basal bone did not differ significantly between the two groups. In the Class II Division 1 sample, there was a highly substantial association between basal and dental arch forms in the canine and molar areas, and the FA and WALA point arch forms were extremely individual. Both the Class I and Class II samples had roughly the same mandibular dental arch shapes, with the exception of the canines, which is likely owing to the pattern of the occlusion in Class II Division 1 individuals. The arch shapes of the basic bones in the two groups were identical.

WALA points or other anatomic markers of the basal bone could be used to forecast a patient's optimal dental arch form, resulting in a more consistent orthodontic treatment outcome.

Gupta et al (2010) [49] In adults and children with Class I and II malocclusions, the dental and basal arch forms of the mandible were compared, and the Class II Division 1 mandible was found to be identical to the Class I mandible in terms of basal bone and dental arch proportions. WALA points can be used to distinguish between different types of dental arch shapes in children and adults., i.e., "Unique to every individual”

Moura Neto (2010)[50] assessed the WALA ridge in dissected mandibles and casts as well as its measurement in occlusal radiographs and tomographies and said that the method was viable.

Conti (2011)[51] stated that because the preservation of this arch form and dimension is a significant component for orthodontic treatment stability, the mandibular arch form is considered one of the major standards among diagnostic tools. The WALA ridge was used to individualise the mandibular arch shape and to predict changes in mandibular intercanine and intermolar widths during orthodontic therapy and 3 years after treatment. A total of 20 patients (12 women and 8 men) were included in the study, with an average age of 20.88 years. The intercanine and intermolar distances in the centre of the facial surface of the clinical crown, as well as the width of the WALA ridge, were measured using the dental casts from the initial, final, and post-treatment evaluations. Amongst the three stages studied, there was a statistical difference in intercanine and intermolar distances. These distances increased dramatically with treatment and decreased in the post-treatment period, but did not return to their pre-treatment levels. Hence, it was concluded that the WALA ridge approach, which was utilised in this study to create individualised diagrams and quantify intercanine and intermolar distances, was found to be beneficial in terms of individualising dental arches and improving post-treatment stability.

Kim (2011)[52] determined the relationship between dental and basal arch forms, analyse differences in tapered, ovoid, and square arch forms in normal occlusion using 3D virtual models, and test the hypothesis that the overjet and maxillomandibular basal arch width variation have a significant positive correlation. Three-dimensional scanning was used to assess 77 typical occlusion plaster casts. Rapidform 2006 software was used to digitise the facial axis (FA) and WALA points. Both dental and basal arches, as well as the overjet, were measured. According to arch shapes, the samples were divided into three groups: Twenty participants were included in tapered group, twenty in ovoid one, and thirty- seven in square group. It was found that the tapered arch shape had a greater mandibular intermolar depth than the ovoid in terms of basal arch dimensions. Both the upper and lower arches had strong relationships between the correlation. The conclusion of the study was that the three dental arch form categories varied only in some skeletal arch parameters. The basal and dental intercanine widths were shown to have moderate relationships. These data imply that the dental arch form may not be determined primarily by the basal arch.

Weaver (2012)[3] assessed modifications that were made to the dentoalveolar (WALA Ridge) and dental arch widths, as well as tailored archwires are tailor-made; during Orthodontic therapy. Prefabricated archwires and customised archwires were used to treat 20 patients each. The deviations in the dentoalveolar and dental arch width were calculated at the cuspid, bicuspid, and the molar region using pre- and post-treatment mandibular casts (T1) and (T2). Transverse dental to dentoalveolar movement ratios were estimated as well. The lower casts were seen at two alike time intervals, the results were then equated to an untreated control group. When equated to the control group, the prefabricated archwire showed considerable changes in dentoalveolar and dental arch width. However, when customised arch wire are compared with the control group, no substantial variances in dentoalveolar and dental arch width were observed. The dentoalveolar and the dental arch width was found to have substantial relationships. The ratios of the dental to the dentoalveolar transverse change, on the other hand, were unlike between the groups, demonstrating that the sorts of motions differed amid the prefabricated and the custom-made arch forms as they extended the dental arches. Therefore, it turns out to be a constant landmark, when the archwires are tailored or contoured to the WALA ridge. When the prefabricated archwires are utilised that do not comply to the dentoalveolar arch width of the patient, which is determined by the WALA Ridge, changes in the WALA Ridge are predicted. This is most likely due to the varied types of tipping and extrusion techniques used by both procedures.

Shahroudi (2012)[53] established that one of the most crucial aspects of the dentition is the dental arch form. However, in diagnostic and treatment planning, this dimension is commonly unnoticed, and orthodontic patients are typically categorised based on their sagittal appearances. The investigators wanted to see if there was association amid the dental arch width (transverse measurement), the sagittal skeletal and the dental variables in patients requiring orthodontic treatment. A total of 108 untreated Iranian individuals (47 men and 61 women) amid the ages of 16 and 31 were evaluated using dental casts and lateral cephalograms. A computerised calliper was used to measure AW such as UIMW and LIMW, UICW and LICW. Sagittal measurements encompassed the SNA and SNB angle, as well as Wits' assessment from lateral cephalograms, and maxillary and mandibular arch length from the dental castings (UAL and LAL). Pearson association coefficients were used to evaluate the association between the aforesaid parameters. Angle's classification was used to record molar and canine relationships, and the average of all variables was equated across three different occlusal relation and gender groups. SNA and UICW, as well as LICW and LAL, have a momentous positive association between sagittal characteristics and arch width measurements, according to statistical analysis. The association amid upper and lower ICW was substantial, as was the association among the upper and the lower IMW and UAL and LAL. Both the UAL and LAL are linked with the ANB angle among sagittal measurements. In three different occlusal classes, the average of arch width characteristics was not substantially different. It was determined that only the UICW and the SNA angle, as well as the LICW and the LAL, showed a weighty association amid arch width and the sagittal parameters. The arch width parameter did not vary significantly across the three occlusal classes.

Bhandari (2012)[54] determined the distances amongst the alveolar process and mandibular permanent teeth in Himachali people who had normal occlusion. Fifty mandibular castings with permanent dentition were selected from untreated Himachal residents. The ranges between the dental reference points and also the alveolar process for each tooth were premeditated using a computer software. The distances between the incisors and molars amplified progressively from 0.00 to 2.46 mm, according to the findings. So, when equated to Americans with normal occlusion, Himachalis with normal occlusion have higher lingual crown locations for incisors, premolars, and molars.

Lombardo (2013)[55] The goal of this investigative study was to express a Caucasian arch shape, including dentition and alveolus, and compared it with the form of the most popular archwires in the market. 35 sets of tooth casts from Southern Europeans who had normal occlusion was collected for this investigation. Subsequently the dental impression casts were scanned, 3D software decided the coordinates of the alveolar bone (WALA ridges) dental arches (FA points). Curves in lieu of the maxillary and mandibular teeth, along with those signifying the contour of the mandibular underlying bone, were plotted and related with those corresponding to several categories of recurrently used archwires for orthodontic purpose for each individual. The idyllic forms of the lower alveolus, as well as the maxillary and mandibular archwires, were computed and equated to those that are currently available. Significant alterations between the two were discovered by statistical analysis, predominantly at the upper and lower canines and molars. Except for the intercanine width, there were momentous discrepancies in the forms of the existing WALA ridge and the existing archwires. It was determined that, hardly any of the manufactured archwires tested precisely coordinated the geometry of the 'ideal' dentition that we computed, especially at canines and molars. During orthodontic treatment, the osseous construction of the mandibular buttress cannot be used as a reference to the determine outline of the various arch forms.

Shu (2013)[56] In this study, the maxillary and mandibular posterior teeth in the Angle's Class II div 1 malocclusion were compared to those in Angle's Class I occlusion, based on arch and alveolar width along with the buccolingual inclination.

The mandibular and maxillary arch widths, as well as the first molars and premolars alveolar width, were measured using a digital calliper on 45 individuals having Angle’s Class I occlusion, and Angle’s Class II div 1 malocclusion each. A revised universal bevel protractor was used to assess the mandibular and maxillary bicuspid and first molars buccolingual inclination. In both groups, all of the posterior teeth were inclined lingually. In Angle’s Class II div 1 malocclusion, the maxillary bicuspid along with first molars were noticeably inclined more towards the lingual direction than in Angle’s Class I occlusion. In Angle’s Class II div 1 malocclusion, the mandibular first bicuspids were much less inclined towards the lingual portion than in the Angle’s Class I occlusion. In mandibular second bicuspids and first molars, there was no significant variance in buccolingual inclination amongst the two groups. The maxillary and mandibular arch widths, as well as alveolar breadth, did not vary significantly between the two groups. Hence, it was stated that buccolingual inclination, not arch width or alveolar breadth, is a key factor in Angle’s Class II div 1 malocclusion transverse incongruity.

Suk (2013) [57] The main objective of this study was to use CBCT to estimate the association amid the lower basal and dental arch shape in patients with normal occlusion to those in Class III malocclusion. 32 normal occlusion subjects (19 men, 13 women; 24.3 years of age) and 33 Angle’s Class III malocclusion individuals (20 men, 13 women; 22.2 years) were preferred from CBCT pictures. Starting from left to right lower first molars, the facial axis and root centre sites were found. For each arch shape, the distances amidst the face axis and root centre points were premeditated, and four linear and two variable ratios were assessed and premeditated. To differentiate the variables amid groups an independent t-test was used. Within each group, the Pearson correlation coefficient was accustomed to analyse the connotations amongst dental and baseline factors. The mandibular basal and dental intercanine widths in the Angle's Class III group were noticeably higher than in patients with normal occlusion (p 0.05). In normal occlusion, the basal along with the dental intercanine widths, and also basal and dental intermolar widths, were substantially linked, while in Angle's Class III malocclusion, they were fairly correlated. Inferences were made that, in the regular occlusion group, the dental arch shape exhibited a high positive association with the basal arch shape, while in Angle's Class III malocclusion group, the relationship was low. These conclusions may aid doctors in improved understanding the significance of shape of basal arch in the alveolar ridge.

Murshid (2013) [58] The orthodontic literature divulges a lack of agreement on how to determine the dimensional accuracy of the dental arch form in an unfailing and definite manner. To pick the arrangement of the arch wire to meet a specific dental arch, several visual, linear, geometrical, and mathematical approaches were used. Investigators and orthodontists agree that the arch form has no universal shape and that the particular mandibular arch form should be kept. This idea has been transferred for manufacturing of the treatment arch wire for an individual utilising a pretreatment study cast by many vendors. Arch wires were custom-made for each individual using the Insigna and Sure Smile systems. Andrews and Andrews (2000) tactic for defining mandibular individual arch form (WALA ridge) is promising, and a recent study found a positive connotation between this process and treatment arch wire arch form shaping.

Yazeed (2013) [59] A paediatric dentist's primary concern is the dental arch character, which plays a crucial role in ensuring a unified shift from deciduous to permanent dentition through mixed dentition. The objective of this research is to set guiding principle for several dental arch measurements in Egyptian youngsters. 382 maxillary and mandibular dental casts for 191 children (69 girls and 122 boys) between the age of 6 years to 12 years with complete dental and normal occlusion were elected from the documentations of the dental office of the National Research Centre in Egypt. According to the age of the patient, the casts were divided into two groups [Group. I (6 years to 9.5 years) and Group. II (9.5 years to 12 years)]. A digital photo tracer was used to scan and digitise the casts. Certain linear distances were premeditated from the digitised reference locations in order to compute the width, perimeter, and depth of the dental arch. It was found that for males, almost all of the maxillary and mandibular arch width was ahead. Well within second age group, there was a sizable gender discrepancy in arch perimeter, with girls being slightly ahead. In the second age group, there was a considerable alteration in arch depth in the higher posterior area, with boys being ahead and girls being ahead when measuring lower anterior depth. In due course, the findings shed information on the complete dental arch proportions for Egyptian youngsters across the age spectrum inspected. As an outcome, instead of formulating norms from different ethnic groups, clinicians should utilise the stated standards for Egyptian children.

Prado (2014)[60] The surgery of choice for grown-ups with a transverse maxillary deficit larger than 7 mm is SARME. The dento-skeletal impact of an orthodontic retainer on the consequence of SARPE is a question of discussion. The objective of this study was to see how effective an orthodontic retainer is at sustaining dentoskeletal stability. A total of 90 digital dental models from 30 adults undergoing SARME were scrutinized and alienated in two groups: group 1 that is no retention (n ;5 15) and group 2 that is retention (n; 5 15). The dental casts were taken at three different times: (1) 7 days former SARME (preoperatively), (2) follow up 4 months later expansion, and then (3) 10 months later, when the expansion was finished. At checkpoint 2, the individuals in the retention group received a transpalatal arch shortly afterwards the expander was removed. After the enlargement, the received transpalatal arch was retained for a duration of ten months. A laser image scanner was used to scan the dental casts. The distances inspected were bicuspid and molar intercusp distance, intercervical ranges of bicuspids and molar, the inter WALA ridge distances of premolar and molar and height of palate at the upper first molar. The expected upper arch expansion was completed in the projected time frame. The height of palate fell by 0.79 mm (4.38 percent) at the 4-month time period interval and by 0.38 mm (0.98 percent) at the 10-month interval, but not considerably in both groups. In the no-retention group, the premolar intercusp distance reverted by 1.84 mm (7.18 percent) at checkpoint 3. At checkpoint 3, both groups displayed average bicuspid intercervical distances of 0.95 mm, bicuspid inter-WALA ridge lengths of 0.88 mm, the molar intercusp distances of 1.04 mm, the molar intercervical distances of 0.74 mm, and molar inter-WALA ridge ranges of 0.84 mm. According to the investigation of relapse in both groups, it was inferred as dento-osseous stability is not increased by the adoption of transpalatal as a retentive device, according to the investigation of relapse in both groups.

Fonseca (2014) [61] When orthodontic treatment is accomplished, the degree of transversal development in the lower arch can be evaluated with WALA ridge assessment. The Wala ridge assessment was used to assess the mandibular arch shape in the treated patients with passive as well as dynamic self-ligation techniques. The lower castings of 39 treated patients who were treated with the Damon, Quick, and In-Ovation systems (13 each) were used in the study. In the initial and final lower casts, the Wala ridge of cuspids, 1st and 2nd bicuspids, and 1st and 2nd molars were evaluated and equated to Andrew's reference values that are (0.6, 0.8, 1.3, 2.0, and 2.2 mm, respectively). Patients treated with the Damon system had final cast readings of 0.4, 0.4, 1.3, 1.9-, and 1.8-mm. Readings in the In-Ovation system were lesser as compared to the readings of Quick System 0.2, 0.4, 1.3, 1.9, and 2.0 mm. The three systems allowed for transversal growth of the arches. In spite of the fact that the Quick method came bordering, none of the systems accomplished Andrews' ideal post-treatment principles.

Andrews (2015)[5] While archwires that are not designed like the WALA ridge may help to enhance the smile and straighten the teeth and, the roots will not be centred inside the alveolar process and over the basal bone. Archwires that are not designed like the WALA ridge, may enhance the smile and straighten the teeth; however, the roots will protrude through the basal bone and not be centred inside the alveolar process. Directions are indicated by the shades black, green and red which are (too distal, narrow, or short), (harmonious), and (too anterior, wide, or tall), respectively. The distances are shown by millimetres.

Zou (2015)[62] The objective of this study was to use 3-dimensional digital models to observe the skeletal Class III patients and the severity amidst both the mandibular dental arch and basal bone arch forms. A laser scanning technology was used to build 33 virtual pretreatment mandibular models. The basal and dental arch types were epitomized by the most protuberant areas present on the tooth surface (FA) and the utmost noticeable spot on WALA ridge. The FA and WALA curves showed a moderate-to-high connotation, particularly in the molar, canine and locations. In the anterior teeth region, the WALA curve has a higher radius of curvature compared to FA curve. FA had higher coefficients of variation than WALA in the molar and canine areas (5.42 percent, 3.88 percent, 8.53 percent, and 7.22 percent) (6.70 percent, 6.01 percent, 15.30 percent, and 9.97 percent). The comparative standard deviations of the cuspid area were larger than that of the molar region for the FA and WALA points. Both slopes were tailored to the individual. The basal bone and dental arch shapes were shown to have a moderate-to-high association. As compared to the WALA points, FA points are positioned more towards lingual direction. Much higher discrete disparities were seen in the canine area.

Solekah (2015)[63] The archwire used in fixed orthodontics with the Begg approach is formulated from a chart with a curved shape and size fluctuation. The chart was preferred based on the summation of the mesiodistal breadth of the upper and lower arch's six anterior teeth. The motive of this study is to ascertain the influence of archwire use in fixed orthodontic treatment with the Begg technique on the width and shape of the dental arch utilising measurement sites of WALA ridge. Before and after therapy, the study looked at 41 patient study models. The teeth arch shape was designed using the upper and lower tooth's face axis points, which were then overlaid on a pentamorphic teeth arch shape template, and non-parametric crosstabs was used to analyze the data. The inter canine and inter molar of the maxillary and mandibular arch were evaluated on the face axis point, and paired t-test was used to analyze the data. According to the conclusions, , the lower arch is normal,while the majority of upper dental arch forms are tapered and normal. The intermolar width of the upper and lower constriction of the dental arch. The shape and width of the dental arch following fixed orthodontic treatment using the Begg technique are in agreement with the archwire employed, according to the findings of this study.

Lombardo (2015)[64] The goal of this study was to see if there was any association between ethnic background and the size and shape of the dental corridor and its bony reinforcement, using 3D software, and to look into the connectivity between the two variables within each ethnic group. The information received was compared to the dimensions of commercially available pre-formed archwires to see which one fit each arch in each group the best. The linear intercanine, inter-premolar, and inter-molar measures, overall arch length, and the length between every tooth and the reference occlusal plane were compared in 29 African-American and 37 Caucasian patients' dental and alveolar arches. The in-out of the brackets was studied to identify which pre-formed archwires are suitable to each of the two ethnic groups, imitating their presence in the mouth cavity. The upper and lower dental arches, as well as the alveolar arches, were all wider and lengthier in African subjects than in Caucasian subjects. In general, "Roth small" (index value 1.556) and "Ideal Form Medium" (index value 0.645) archwires in the latter group were best adapted to both upper and lower arcades, whereas "Damon" (index value 1.447) and "Ideal Form Large" (index value 1.695) archwires in the former group conformed better to the size and shape of both arcades. There are considerable variances in arch form between the two ethnic groups studied, and the market's selection of premade archwires does not account for patient anatomical heterogeneity.

Dindaroglu (2016) [65] The purpose of this study is to examine if there is a definite association amid both the curve of Spee (COS), the WALA ridge to WALA-FA dimension, and the CW, also if CW and WALA-FA dimension alter the COS widening. 50 volunteers, ranging in age from 20 to 35, had their mandibular replicas scanned using TRIOS. After defining the xyz coordinate structure, a baseline occlusal plane was built. The depth of COS, the CW, along with the WALA-FA dimension were calculated using engineering operating system. In the first molar teeth, the most significant difference in COS depth measurement between both the right & left molars teeth was recorded to be 0.410.50 mm. There was no robust association amongst both the depth of the COS, the CW, and the WALA-FA dimension. There was no association amid the depth of COS, CW, and WALA-FA distances. The CW and WALA-FA spacing may not be useful for deepening of COS.

Anzilotti (2016) [66] and co-workers discovered that transverse skeletal disparities of 5 mm are risk marker for gingival recession and periodontal disease .

Mueez (2016) [67] Between Class II division 1 malocclusion and Class I occlusion, the buccolingual inclination of maxillary and mandibular posterior teeth was measured. A bevel protractor was used to evaluate Buccolingual inclination of maxillary and mandibular premolars and first molars in 25 patients with Class I occlusion and 25 subjects with Class II division 1 malocclusion. In both groups, all of the posterior teeth were lingually inclined. In Class II division 1 malocclusion, the maxillary premolars and first molars were considerably more lingually inclined than in Class I occlusion. In Class II division 1 malocclusion, mandibular first premolars were much less lingually inclined than in Class I occlusion. Buccolingual inclination in mandibular second premolars and first molars did not differ significantly between the two groups. Buccolingual inclination is essential in Class II division 1 malocclusion transverse discrepancy.

Kong Zarate (2017) [68] The motive of this investigative study was to study the measures amongst the lower posterior teeth and WALA ridge in Peruvians having normal occlusion. They collected 65 dental casts from people who had normal occlusion. All posterior teeth were inspected, with the exception of the third molars. The horizontal dimensions amid the occluso-gingival centre points of the buccal borders of an individual tooth & the WALA ridge were evaluated by utilising an improved digital calliper. Amongst the 4 tooth forms, there were statistically significant differences. No discernible variances in gender, side of the arch, or the age groups were found. The horizontal lengths amongst the lower posterior teeth & the WALA ridge amplified gradually as of the 1st bicuspids to 2nd molars in individuals having normal occlusion. The WALA ridge worked as a valuable referring point for establishing the locations of posterior teeth in individuals having normal occlusion.

Mawaldi (2017)[69] The purpose of this work is to compare the transverse dimensions of the jaws, derived from standard PA cephalometric radiographs and with the similar relevant values produced by means of CBCT. Twelve participants' data were taken from the Orthodontic Department's clinical records. All of the subjects had their permanent teeth in occlusion, and their original records included high-quality regular (2D) and CBCT (3D) photos. The participants were split into two groups: posterior cross-bite and non-cross bite. For the sample, the ratio of maxillary to mandibular horizontal widths was computed. The average ratio of maxillary to mandibular jaw widths was 0.75 on normal radiographs and 1.04 on CBCT scans in patients without dental cross-bites. On standard radiographs, the overall mean of these widths was 0.70, and on CBCT scans, it was 0.9 in participants with dental cross-bites. When traditional cephalometric radiographs are compared to the relevant ratios acquired from CBCT scans, the maxillary to mandibular width ratios differ. According to CBCT scans, the ratio of maxillary to mandibular width is on the order of 1:1.

Suzuki (2017) [70] The purpose of this study was to use three-dimensional dental cast analysis to investigate the relationship between the labio-lingual position of the mandibular dental arch form and the corresponding basal arch form in skeletal Class III patients with mandibular prognathism who were implied for mandibular setback surgery, and to compare the results to those of participants with orthodontically unmanaged Angle Class I normal occlusion. A total of 56 skeletal Class III participants with mandibular prognathism (MP-group) and 56 control individuals (C-group) with Angle Class I normal occlusion had their mandibular dental castings analysed. The FA and WALA points were located to evaluate dental and basal arch shapes, and eight linear measurements and six ratio factors were produced. The dental and basal arch morphologies were reviewed and compared between the groups. The dental arch widths, basal arch widths and depths, and the basal arch ratio were all bigger in the MP group than in the C group, although the dental arch depth was reduced. From the central incisor through the second premolar, the FA sites in the MP group were far more lingually positioned, while the first molar was more buccally positioned. In both groups, there were significant positive relationships between dental and basal arch sizes and ratios. In the MP-group, the morphological properties of the dental and basal arch forms, as well as the dental arch form-basal arch form connections, imply that dental cast analysis could be used to determine an individualised therapy target for dental decompensation.

Babicz (2018)[71] Each person's dental arch is different in terms of shape and size. Scientists have laboured tirelessly over the years to describe the components of the human dental arch. In general, there are two classification methods: one that is easy and one that is more difficult. It is thought that keeping the original shape of the dental arch during orthodontic treatment increases the likelihood of a successful outcome, and that correctly recognising the shape of the dental arch allows for the creation of a stable, functional, and aesthetic occlusion. As a result, selecting an orthodontic arch is among the most crucial aspects of orthodontic diagnosis. The study's goal was to go over previously published material on the subject and analyse the relationship between the native form of the dental arch and the contours of prefabricated arch wires used in orthodontic treatment in order to choose the best method for determining the orthodontic arch's shape. The following medical databases were used to conduct the literature review: PubMed, Cochrane, and Embase. Dental arch, dental arch shape, optimal dental arch, arch wires, premade arch wires were some of the key phrases employed in the study. A review of Polish medical journals was also conducted. In the end, 28 publications were found to be eligible for study. Correct identification of the curvature of the dental arch is an important aspect of orthodontic diagnosis since it impacts the orthodontic treatment's course and stability. Uncontrolled alterations in the dental arch are less likely, boosting the sustainability of treatment outcomes. Despite the need of carefully evaluating the morphology of the dental arch and selecting the appropriate orthodontic arch for each patient, professionals rarely do so. One of the key results of the literature study in relation to the aforementioned issues is that more studies in this field of orthodontic therapy is needed.

Gonzalez (2018) [72] In order to establish coordination and harmony of the dental arches at the end of therapy, orthodontic diagnosis must be performed in all three planes of space. The goal of this study was to see how sensitive and specific the Ricketts' PA radiographic analysis, the Penn cephalometric analysis, and the Hayes model analysis with the CAC were. 100 Cone-Beam CT scans, 100 posteroanterior radiographs, and 100 digital models from 50 patients with normal occlusion and 50 patients with skeletal transverse discrepancy were used in a descriptive, cross-sectional, and comparative investigation. With the CAC, we did Ricketts' PA radiographic analysis, Penn cephalometric studies, and Hayes model analyses. The sensitivity, specificity, and predictive value of the positive and negative tests exceeded 85% in all transversal analytical comparisons. The Ricketts' PA radiographic analysis has higher diagnostic specificity, whereas the Penn cephalometric analysis and the Hayes model with the CAC have higher diagnostic sensitivity.

Bulyalert (2018)[73] The goal of this study was to use cone-beam computed tomography (CBCT) images to classify alveolar arch forms and assess variations in alveolar bone density among arch forms in the anterior aesthetic region. At a depth of 3 mm below the cementoenamel junction (CEJ) of the right and left canines, axial views of 113 CBCT images were evaluated. As reference points, the root centre points of teeth in the anterior aesthetic zone were chosen. The transverse dimensions of arch types and the intercanine width-to-depth ratio were used to classify them. Each tooth's buccolingual alveolar bone thickness was measured three millimetres underneath the CEJ and at the mid-root level. The differences in mean thicknesses between arch shapes were investigated. Long narrow, short medium, long medium, and long broad arches were shown to be the most common types of anterior maxillary arches. At both levels, there were substantial differences in buccolingual alveolar bone thickness among the arch groups. The thickest bones were found in the long broad arches, followed by the long medium arches, and the thinnest in the long narrow and short medium arches. Long narrow, short medium, long medium, and long wide were the arch types classified. The thickness of the buccolingual alveolar ridge varied significantly between arch types.

Esteves (2019)[74] To specific insight in WALA ridge and mandibular dental arch proportions in orthodontic treated patients with a passive self-ligating system against traditional braces. Original paper design. Pretreatment (T1) and posttreatment (T2) dental casts of 60 individuals with Class I malocclusion treated with minor to moderate crowding. 30 patients in Group 1 were treated with a passive self-ligating device, with an average age of 17.68 years and a mean treatment length of 2.31 years. Group 2: 30 patients treated with traditional equipment, with an average age of 19.23 years and a 2.56-year treatment period. To evaluate the transversal dimension behaviour of the mandibular dental arch and the

WALA ridge width, measurements were taken directly on pre and posttreatment dental casts using a digital calliper. Results: Self‑ligating group showed a significant increase in WALA ridge width and mandibular horizontal proportions substantially larger than the conventional group, excluding intermolar cusp tip range and intercanine WALA ridge. There was no quantitatively significant difference between the groups. When comparing the WALA ridge rise to the transversal buccal axis dimensions in the premolar area, the premolar area showed a substantially larger increase. When compared to a traditional appliance, treatment with a passive selfligating system resulted in a considerably higher rise in WALA ridge width and mandibular arch dimensions.

Rasmussen (2019)[75] The orthodontist can use the assessment of mandibular molar inclination to evaluate posterior functional occlusal relations, diagnose and treat transverse skeletal and dental relationships, and assess the quality of orthodontic treatment completing. Radiographs and diagnostic dental models are used in traditional evaluation methods. The physician would benefit from the discovery of a clinical anatomic reference that can be verified chairside and consistently achieves desired treatment outcomes. The WALA ridge, a mandibular anatomic landmark, was compared to plaster dental casts of 60 posttreatment patients for mandibular molar inclination using (ABO) Cast-Radiograph evaluation standards. Mandibular first molars that met ABO criteria had an average horizontal WALA-facial axis (FA) distance of 2.56 mm, which was considerably less than the 3.11 mm reported in ABO nonconforming molars with vertical cusp height disparities of >1.0 mm to _2.0 mm. WALA/FA distances of _2.5 mm were not significantly more likely than WALAFA distances of >2.5 mm to be ABO compliant in mandibular first molars. Horizontal tooth to mandibular bone distances are significantly smaller in mandibular molars with vertical variances in buccal and lingual cusp heights that meet ABO standards for inclination (WALA-FA).

Glass (2019)[76] The steadiness of teeth following orthodontic treatment, and the soundness of the periodontium, is reliant upon exact tooth location throughout all components of space while relating to the fundamental bone points. It was to decide if: 1) mandibular posterior teeth are located further centrally in the basal bone assuming that they are more uptight or near Andrews' WALA Ridge standards; 2) lower posterior teeth are substantially centred further in alveolar bone when they are more upright or near Andrews' WALA Ridge standards; 3) assessed focal point of resistance for lower posterior teeth is regularly positioned in the alveolar bone and 4) the WALA Ridge is positioned. The review contained, pre-treatment CBCT images and lower casts from 34 individuals in the age from 12 to 18. Six Elements programming was utilized to gather flat estimations of WALA Ridge. These WALA Ridge vertical readings were produced from the castings utilizing a mechanized calliper. The coronal CBCT pictures were utilized to evaluate the tooth locations for pre-treatment lower posterior teeth nearby encompassing osseous structure. The tendency of the teeth, as well as the place of the WALA Ridge, were assessed and contrasted with focusing of the teeth inside the bone: D1, D2, D3, and D4. There was actually no factual importance in centricity of lower posterior teeth above basal bone when mandibular posterior teeth were further upstanding and closer to WALA Ridge principles. Whenever mandibular posterior teeth were more upstanding or closer to the WALA Ridge standards, there was actually no factual importance in centricity in the alveolar bone. Huge adjustments inside lower posterior teeth centre of resistance being focused inside alveolar bone were recognized regardless of the long axis inclination or WALA Ridge. Whenever the Wala Ridge was situated at it or close to mandibular posterior teeth's focal point of resistance, critical changes were likewise noticed (p- 0.05). 1) Mandibular posterior molars with a more prominent axis tilt or a nearer vicinity to the WALA Ridge marker are not all the more halfway situated over the basal bone. 2) Teeth with longer axis tilt and teeth all the more firmly related with the WALA Ridge marker are not exactly halfway situated in alveolar bone. 3) Center of resistance from all lower posterior teeth, irrespective of inclination, is generally usually arranged in the alveolar bone. 4) The WALA Ridge is situated at it or close to the focal point of resistance for all lower posterior teeth. 5) If teeth were tipped to a vertical stance, WALA Ridge might be a potential biomarker for changing the type of the mandibular curve.

Tremont (2020) [77] The WALA ridge is a valuable milestone for a orthodontically changing lower dental arch shape. Upper transverse skeletal measurement may be calculated by comparing the cusp distance of maxillary posterior teeth to the fossa length of mandibular posterior teeth. Using lower dental arch shape as model, the maxillary arch form is constructed. A harmonized maxillary arch wire should be implanted only after upper transverse skeletal incongruity has been modified. The contemporary idea for evaluating anteroposterior jaw location is "treatment planning towards a smiling profile," that employs glabella vertical as external reference. The most straightforward method for levelling the Spee curve is really to tripod lower arch during surgery & then level it later.

Lima (2020)[78] WALA ridge post-treatment dental cast dimensions of the WALA ridge were raised by 5mm at premolars. This arch expansion was achieved not only through lateral tooth movement, that expanded its intercanine, interpremolar, and intermolar widths, but also through alveolar bone remodeling after tooth movement.

Esmaeili (2020)[79] Because the basal bone and dental arch indices are important in defining treatment plans for orthodontic patients, current study employed CBCT imaging to assess dental arch and basal bone indices in Angle's Class I & II patients. This study used CBCT images from 66 individuals having Class I (0ANB4) & Class II (ANB>4) skeletal & molar connections. The patients' age varied from 15 to 35 years. The dental indices of intercanine width and ratio, as well as intermolar depth, were found to be higher in Class II patients than in Class I patients, while the intermolar ratio of Class I individuals was found to be higher than that of Class II patients. In Class I patients, the intermolar width and ratio were higher, while Class II patients had a higher basal arch index of intermolar depth. With intercanine depth difference, the transverse dental and basal indices are equivalent. According to the correlation data, there is a strong relationship between intercanine width, intermolar depth, intermolar ratio, & intermolar width in both groups, & a moderate relationship between intercanine depth and intercanine width.

Shreshtha (2020)[80] The horizontal distance between the WALA ridge & the mandibular posterior teeth was assessed in individuals with normal occlusion. Following ethical permission, an analytical cross-sectional investigation was carried out. The study included 130 dental casts from Nepali persons (46 men & 84 women) with normal occlusion. With the exception of third molars, WALA ridge &

FA (facial axis) positions of each mandibular posterior tooth were identified. A modified vernier Calliper was used to measure the horizontal distance between FA & WALA ridges . Except for the 1st molar, gender differences in FA to WALA horizontal distance were statistically significant. On the arch side, however, there have been no statistically significant variations between boys and girls for all teeth. Males had a first premolar FA - WALA ridge distance of 0.6 mm, a second premolar FA - WALA ridge distance of 1.16 mm, a first molar FA - WALA ridge distance of 1.71 mm, and a second molar FA - WALA ridge distance of 2.41 mm. Females had the first premolars that measured 0.4 mm in length, second premolars that measured 0.88 mm in length, first molars that measured 1.72 mm in length, & second molars that measured 2.1 mm in length. The horizontal distance between the mandibular posterior teeth & the WALA ridge grew from anterior to posterior.

Giuca (2020) [81] The purpose of this investigative study was to analyse the form & the average size of upper & lower arch within an Italian teenage population with adequate occlusion by utilising the digital technology. A study sample was made of digital dental casts of 79 Italian teens (39 girls and 40 boys) with normal occlusion, aged 141 years, after employing an extra-oral scanner & applying inclusion and exclusion criteria. On each model, the reference landmarks of the dental arches (FA), alveolar bone (WALA ridges), & the incisal boundary of the central incisors were recognised. These points and software were used to analyse fourteen variables for individual cast: basal & dental intermolar & inter-cuspid width, basal & dental molar & cuspid depth, basal & dental molar & cuspid ratio, overjet, & overbite. Lastly, depending on their form, the arches were categorised as ovoid, triangular, or square. According to the data, the ovoid arch form was the most prevalent, followed by triangular form for maxillary arch & rectangular form for the bottom arch. In comparison to other 2 groups, the triangular shape had the least width and ratio values, as well as the maximum depth values, just on cuspid level, both the upper and the lower, for both dental and basal positions. The square indicated the inverse situation, while the ovoid denoted a neutral value. The pattern is remarkably similar to the canine at the molar level. The findings may imply that a significant proportion of the patients in the sample will utilise a prefabricated ovoid arch wire, & the information gained may be useful in establishing the suitability of present arch wires or designing new ones.

Rick O'Neil (2021) [82] The purpose of this research was to examine if there were any alterations in the archforms generated by analysing the tooth surfaces, the alveolar bone, and the soft tissues that covered them. This research comprised 18 patients, all of whom had an Angle's class I malocclusion, moderate crowding, & a favourable diagnostic CBCT imaging. The FA landmark was used to compute the arch form derived from teeth, whereas Bowman-Kau landmark was used to calculate the arch shape from the alveolar bone, while the arch form from soft tissues was estimated from the WALA ridge. Following that, a predefined algorithm was used to formulate five distinct arch shapes for each individual. Based on their shape, these arch types were categorised and overlaid. The distances between arch forms formed by teeth, bone, & soft tissue were measured. As a result of the results, the predicted lengths among all arch designs differed significantly. The mandible had larger intervals between tooth & bone-derived arch forms than the maxilla. The longer distances looked to be closer to arch's rear than to its front. The biggest gap amongst tooth & soft tissue-derived arch formations was seen in 2nd bicuspid, first molar, & 2nd molar. There were no noteworthy variations in distance between tooth-derived arch forms and arch forms derived from the soft tissues and bone based on gender. The arch forms formed from alveolar bone, teeth and soft tissue are all linked and share an identical fundamental structure. Even though further large-scale study is required, our findings suggest that evaluating clearly apparent outside indicators, like the WALA ridge, can reliably envisage underlying bone structure and, as a result, the anticipated arch form. Nonetheless, because the wire shapes vary so much from patient to patient, the ultimate treatment plan should be adapted to the individual instead of counting on on too basic generic wire shapes.

Chhatwani (2021) [83] SARME is treatment approach for maxillary constriction. During transverse expansion procedure, unwanted asymmetries may occur. The transverse expanding behaviour of the maxilla is evaluated in this retrospective research using a simulation-driven SARME with targeted osseous weakening. CBCT images of 21 individuals were overlaid pre (T1) & post (T2) treatment using simulation-driven SARME in combination with a transpalatal distractor and a targeted osseous weakening. The activities on left segment, right segment, & frontal segment were assessed just at altered WALA ridge, the mid root level, also at the root tip of all maxillary teeth. The linear and angular dimensions were used to spot dentoalveolar deviations. Premolar buccal tilting (6.1° 5.0°) seemed considerable, and dentoalveolar modifications were unavoidable. The transverse expansion of the bicuspid area was more than that of molar region. The growth on the left & right segments did not vary pointedly. Simulation-driven SARME with targeted osseous weakening is useful for achieving proportioned expansion in the transverse plane.

Madero (2022) [84] (CBCT) scans and digital models (n=45 each) were used to determine maxillary transverse proportions in people having impacted maxillary cuspids. The motive was to investigate the correlation between such proportions and impaction, as well as to compare the measurements between both the two approaches. The upper arch width was evaluated on scans and working casts obtained at the WALA ridge, & the intermolar & interpremolar width levels at the 1st & 2nd bicuspids were evaluated. Two assessors individualistically evaluated dimensions in patients with unilateral impactions amongst the control quadrant group (without impaction) as well as the case quadrant group (with impaction), as well as amidst the unilateral & bilateral impaction groups. On CBCT scans of the upper 1st molars at the lingual level and the upper 2nd bicuspids at the WALA ridge level, statistically, substantial variances in transverse measurements were seen amongst the case control & control quadrants in the single quadrant impaction group. Substantial variances were found amongst the case quadrant group in the one-sided vs two-sided groups at WALA ridge on the 2nd bicuspids in casts & the lingual landmarks on 1st molars on CBCT images. The casts and CBCT scans indicated no statistically substantial variances in transverse dimensions amidst the affected buccal & palatal cuspids.

Kato & Arai (2022) [85] There are favourable relationships between mandibular dental & basal arch form morphologies in the people with minimal crowding; but, the link in patients requiring orthodontic treatment and having mandibular anterior crowding (MnAC) is uncertain. 30 women having normal occlusion (average age in years: 20.662.5) & 30 women having Angle's Class I MnAC comprised the control and MnAC groups (mean age: 20.3 6 2.9 years). The width & depths of the mandibular dental arch & basal arch were assessed also related across groups at the FA & WALA phases. Dental arch widths at canines & premolars, as well as depth at canines, varied more in MnAC group. Confident associations were found amongst dental & basal arch widths in both groups, with an exception of the MnAC group at the canine, & higher associations were found among the width of dental arch with all teeth apart from for the 1^{st} molar & width of basal arch for posterior adjacent teeth while associating the equivalent widths of the basal arch. Because of the strong associations amongst the dental arch width and the basal arch width, the basal arch widths at the posterior neighbouring tooth might be employed as an extra locus for constructing a personalised post-orthodontic dental arch shape for MnAC patients.

MATERIAL & METHODS

Untreated subjects of Skeletal Class visiting to the out-patient department for seeking Orthodontic treatment, under were included in the study, in accordance with the inclusion & exclusion criteria. (From OpenEpi Version 3, open-source calculator SSPropor). The sample size was calculated to be 65.

Inclusion criteria

Subjects with

i. Class I skeletal base, straight profile
ii. age group = 16 to 25 years
iii. presence of full complement of dentition, except 3^{rd} molars
iv. crowding not more than 4mm
v. Curve of Spee depth of 0 to 1.5 mm
vi. overjet and overbite of 2 to 4 mm

Exclusion criteria

Subjects:

i. who have undergone orthodontic/ orthognathic treatment.
ii. with severely mutilated dentition
iii. who are medically compromised.
iv. with facial asymmetry and craniofacial anomalies.
v. with periodontally compromised teeth, attrition of teeth, missing teeth, removable or fixed prostheses.

APPROPRIATE STUDY INSTRUMENTS:

- For clinical examination

  Cheek retractors

  Lugol's solution

  Cotton pellet

  Tweezer

  Scale

  Divider & Modified divider

  Marking pencil, etc.

- For model analysis

  Digital Vernier Calliper and modified Digital Calliper

  Marking pencil, etc

METHOD:

- Patients were sorted out according to the inclusion & exclusion criteria.

- Freshly prepared Lugol's solution [*2g potassium iodide + 1g crystals of iodine dissolved in distilled water (60 ml)* (Figure1)] was applied on the mandibular labial & buccal mucosa, with a cotton pledget, using "light pressure burnishing approach". (Fig.5)

- A precise distinction between attached gingiva & alveolar mucosa resulted generally in 30- 60 seconds.

- The WALA ridge was observed as shown in the Fig. 6.

- FA points of mandibular 1st premolar, 2nd premolar, 1st molar and 2nd molar were marked on the clinical crown in vivo. (Fig.7)

- The distance of all the WALA points to FA points were measured intraorally and were transferred on the mandibular dental casts to form the exact replica of the WALA ridge. (Fig.8)

- WALA Horizontal (WH) i.e., horizontal distance between the tangent to facial axis and WALA ridge was measured intra-orally with modified divider (Fig.4) for mandibular 1st premolar, 2nd premolar, 1st molar and 2nd molar. The same was repeated on the cast using modified digital calliper and mean values were obtained (intraorally as well as from dental cast) and noted. (Fig.9 & 10)

- Inter-Canine distance in relation to their respective WR & FA (WALA ridge points and Facial axis points respectively) was measured intra-orally with divider for mandibular 1st premolar, 2nd premolar, 1st molar and 2nd molar. The same was repeated on the cast using digital calliper and mean values were obtained (intraorally as well as from dental cast) and noted. (Fig.14, 15 & 16)

- Inter – molar distance in relation to their respective WR & BA (WALA ridge points and Buccal axis points respectively) was measured intra-orally with divider for mandibular 1st premolar, 2nd premolar, 1st molar and 2nd molar. The same was repeated on the cast using digital calliper and mean values were obtained (intraorally as well as from dental cast) and noted. (Fig.11,12 &13)

- DWALA i.e., the difference between actual & normal values of WALA horizontal for each mandibular 1st premolar, 2nd premolar, 1st molar and 2nd molar was calculated as follows:

DWALA = WH – WALA Horizontal normal values

Tooth type	**WALA horizontal normal values**
First premolar	0.8
Second Premolar	1.3
First Molar	2
Second Molar	2.2

Other related terminologies are listed as follows:

Alveolar Bone – is a particularised portion of the lower and upper bones that is prone to tooth eruption rapid remodelling and the functional needs of chewing. It serves a pillar for teeth in all kinds.

Apical Base/Basal Bone – the bone coincident with the bone where the apices of roots of the teeth are situated, in a horizontal plane. In other words, it is the bone that supports the alveolar bone at the apical third level off lower teeth.

Buccal – the facet of the posteriors which is adjacent to the cheeks.

Center of Resistance – a point in the alveolus through which a force vector will initaate translatory movement. It has been theorised that the Cres is located approximately 0.3 to 0.5 mm from crestal bone to the apex (at $1/3^{rd}$). It has been found to be stable and unchanged.

Center of Rotation – it's a point around which all the points of the object (tooth) rotate. Unlike Cres, it changes & is dependent on the moments & forces.

Dehiscence- Root exposure due to crestal bone loss.

Element I – Proper buccolingual inclination for optimal occlusion and tooth is in the centre of apical base.

Facial Axis of the Clinical Crown (FACC) – The most protuberant part of central developmental lobe of crown of a tooth makes the facial axis. For molars, however, facial axis passes through the buccal groove.

FA Point – point of intersection whose lines divide the crown into gingival and occlusal halves.

Fenestration- isolated denudations of root due to window like bone loss.

Inclination - the tipping of a tooth along its long axis in buccolingual direction.

CLINICAL SIGNIFICANCE:

- This is an in vivo investigation to assess the lower dental archform while relative to FA point alongwith the basal bone structure which is underlying.
- The WALA ridge is simple to identify chair-side.
- WALA points represent the basal archform which can be used as an archwire template to fabricate individualized archforms.
- Basal archform should be considered when altering dental archform. If not done, the treatment will be unstable and periodontal issues can arise.

COLOUR PLATE I

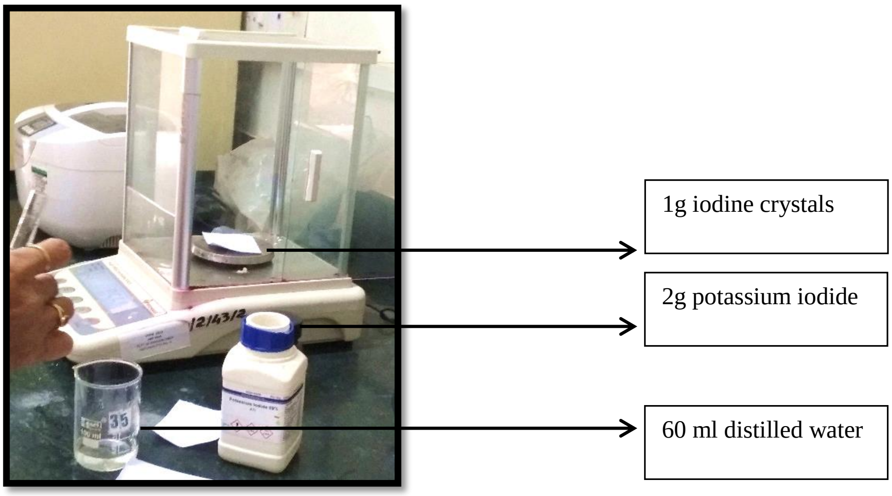


Fig. 1: Armamentarium for Lugol's solution preparation

Fig. 2: Lugol's solution

Fig. 3: Armamentarium required

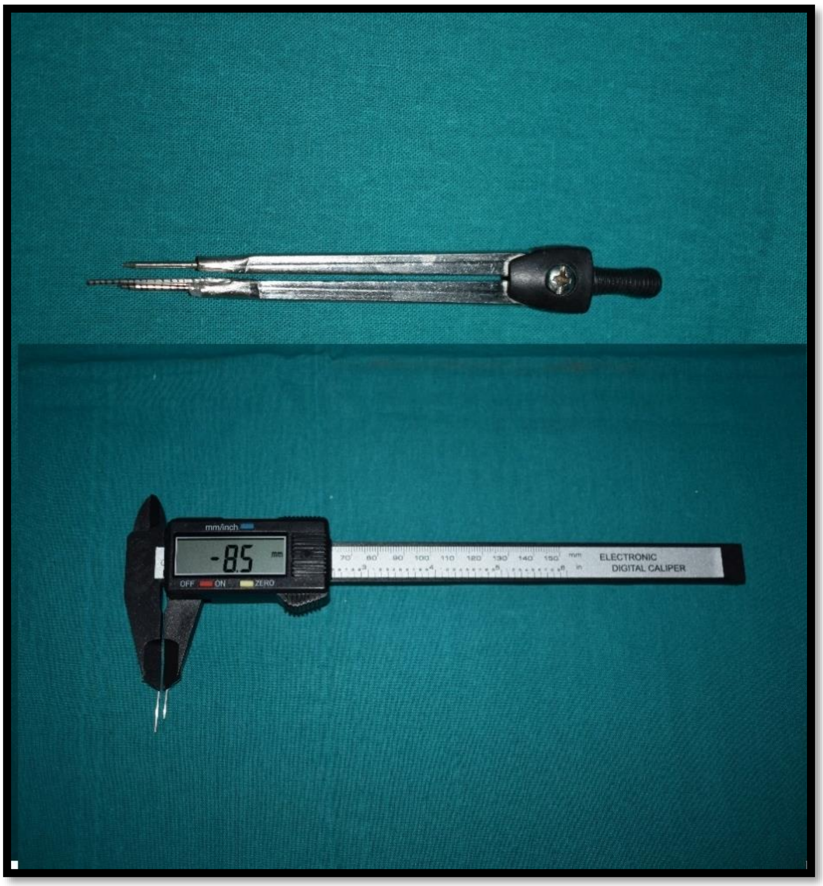


Fig. 4: Modified divider & Modified Digital Calliper shown respectively

COLOUR PLATE II

Fig. 5: Lugol's solution application by 'Light burnishing method' using a cotton pellet

Fig. 6: Superior most portion of MGJ- WALA ridge demarcated by Lugol's solution

COLOUR PLATE III

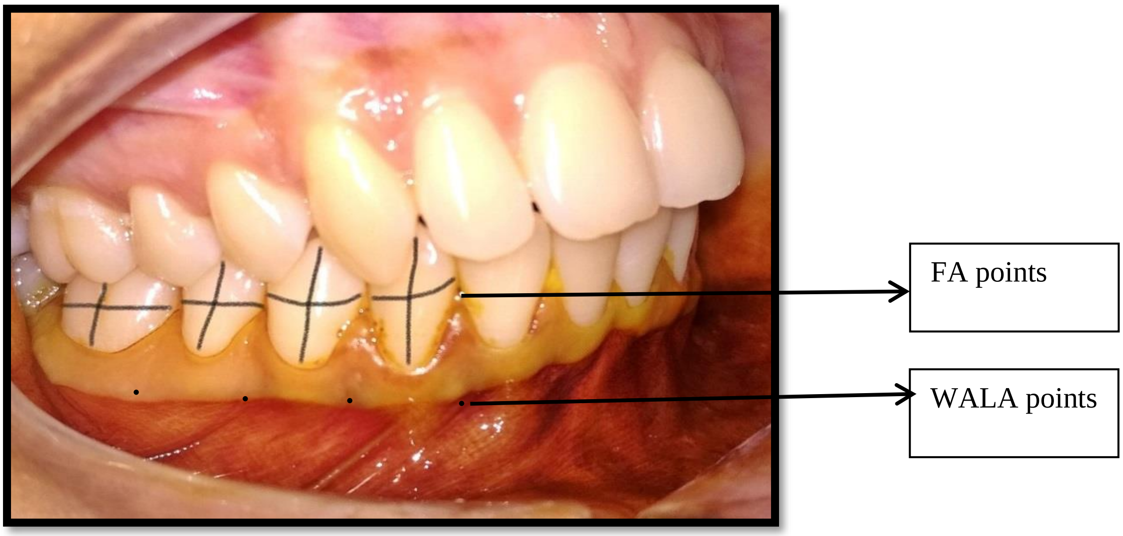


Fig. 7: FA points marked on the teeth using marking pencil.

Fig. 8: FA & WALA points marked on the cast.

COLOUR PLATE IV

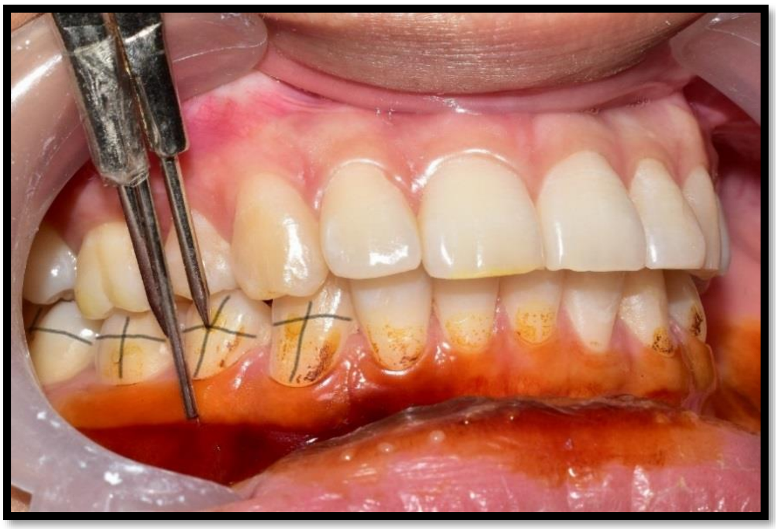


Fig. 9: WH measurement

Fig. 10: WH measurement on dental cast

COLOUR PLATE V

Fig. 11: Inter-molar width according to WALA points

Fig. 12: Inter-molar width according to WALA points on dental cast

Fig. 13: Inter-molar widths according to FA points on dental cast

COLOUR PLATE VI

Fig. 14: Inter-canine width measurement according to WALA points

Fig. 15: Inter-canine width according to WALA points on dental cast

Fig. 16: Inter-canine width according to FA points on dental cast

RESULTS

After comparing the intercanine width according to WALA points and FA points in Skeletal Class I pattern individuals using Unpaired t test ($t = -8.112$), there was no significant difference between them as the mean for FA point was 24.88 and that for WALA points was 26.88, with standard deviation of 1.36 and 1.44 respectively ($p<0.001$). It shows that FA and WALA can be used interchangeably for individualizing the archform.

Next, in the comparison of intermolar distance according to WALA and FA points in Skeletal Class I pattern using Unpaired t test ($t = -7.673$), there was no significant difference between them as the mean for FA point was 51.34 and that for WALA points was 53.3, with standard deviation of 1.59 and 1.3 respectively ($p<0.001$). It shows that FA and WALA can be used interchangeably for individualizing the archform.

The correlation between WALA ridge and mandibular teeth in Skeletal Class I pattern was found to be moderately positive in Intercanine width parameter as the r value was 0.466 obtained by using Pearson 'r' correlation coefficient ($p<0.001$).

The correlation between WALA ridge and mandibular teeth in Skeletal Class I pattern was found to be strongly positive in inter-molar width parameter as the r value was 0.687 obtained by using Pearson 'r' correlation coefficient. This shows highly statistically significant correlation ($p<0.001$).

The comparison of DWALA value i.e., the difference between actual and normal values of WALA horizontal at 1st pre molar by using One sample 't' test value (t= 8.125 for left, t= 11.761 for right) shows highly statistically significance between them as the actual/ study values depicting WALA horizontal are 1.27 (standard deviation= 0.46) and 1.36 (standard deviation= 0.38) respectively for left and right 1st premolars. And the normal values given by Andrews are 0.8 for left and right 1st pre-molars (standard deviation= 0.0). This shows over-estimation of WH values for 1st pre-molar for Indian population ($p<0.001$).

Similarly, the comparison of DWALA value i.e., the difference between actual and normal values of WALA horizontal at 2nd pre molar by using One sample 't' test value (t= 14.871 for left, t= 19.595 for right) shows highly statistically significance between them as the actual/ study values depicting WALA horizontal are 2.31 (standard deviation= 0.54) and 2.43 (standard deviation= 0.46) respectively for left and right 2nd premolars. And the normal values given by Andrews are 1.3 for left and right 2nd pre-molars (standard deviation= 0.0). This shows over-estimation of WH values for 2nd pre-molar for Indian population ($p<0.001$).

Likewise, the comparison of DWALA value i.e., the difference between actual and normal values of WALA horizontal at 1st molar by using One sample 't' test value (t= 11.476 for left, t= 11.735 for right) shows highly statistically significance between them as the actual/ study values depicting WALA horizontal are 2.54 (standard deviation= 0.37) and 2.66 (standard deviation= 0.36) respectively for left and right 1st molars. And the normal values given by Andrews are 2.0 for left and right 1st molars (standard deviation= 0.0). This shows over-estimation of WH values for 1st molar for Indian population ($p<0.001$).

Moreover, the comparison of DWALA value i.e., the difference between actual and normal values of WALA horizontal at 2nd molar by using One sample 't' test value (t= 25.442 for left, t= 27.297 for right) shows highly statistically significance between them as the actual/ study values depicting WALA horizontal are 3.62 (standard deviation= 0.45) and 3.71 (standard deviation= 0.44) respectively for left and right 2nd molars. And the normal values given by Andrews are 2.2 for left and right 2nd molars (standard deviation= 0.0). This shows over-estimation of WH values for 2nd molar for Indian population ($p<0.001$).

DISCUSSION

The discussion will be under following heads:

1) WALA ridge, it’s associated structures and terminologies

2) Brief details of 6 Elements of Orthodontic philosophy

3) Critical appraisal of the findings of the study

“WALA ridge”, as previously stated, is a demarcation which aids to establish the right arch form heading towards the most supreme dental position in the mandible relative to the basal bone. This terminology was coined by the father-son duo- ‘**Will Andrews & Larry Andrews**’ [9] who defined it as “the superior most band of mandible’s muco-gingival junction, which is situated at or just near the centre of rotation of teeth”. This landmark assist in determining the right arch form, which leads to the best position of teeth in the mandible in relation to the basal bone which ultimately results in post-Orthodontic stability and long-term retention.

The "basal bone" or "Apical base" as introduced by **Lundstrom**[7] in 1923 is "the teeth into bone should be located to have better stability in health and function". Collectively, it's the bone that embraces, buttresses, and is continual with the alveolar process3. Later, **Tweed**[22] defined the same as "the bone over which the lower central incisors must be located to form permanent Orthodontic results".

The apical base is said to be the stable landmark and if the teeth are positioned in its centre, the results are more stable. Supporting this, **Lundstrom**[7] theorized that the basal bone remained unchanged to fit the optimal occlusion but rather the establishment of normal occlusion was governed by the basal bone. The 'apical base theory' was widely accepted until 'bone growing theory's' reiteration was done by **Damon**[12] prescription (2005). It's claimed that 70 it works on the principle of passive expansion as bone is laid in response to the forces.

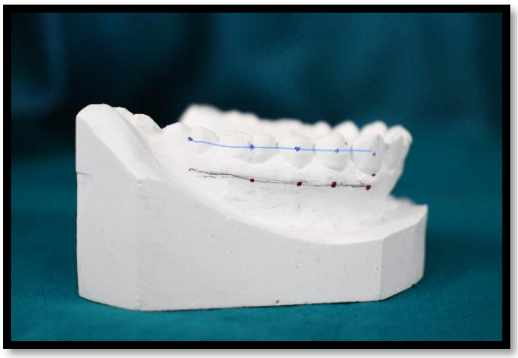
Despite of more inclination towards the non-extraction theory, there always lie anatomical constraints for expansion and space gaining. There was no exclusive method to localize the basal bone which gave birth to the WALA ridge concept which enables us locate the apical base and the ideal shape of the arch.[9]

Andrews[9] hypothecated tipping the teeth with respect to their Cres, to an erect position (expansion of the arches) concentrated within basal bone resulted, when archwires are contoured along the WALA ridge. However, it is uncertain whether it can be extrapolated to the Indian population or not as the previous studies were based on Caucasian population.

Following is a gist to provide insight to each Element:

ELEMENT I:

Dental arches are described by the Element I and are said to be distinguished when teeth are correctly inclined, roots are focalized in apical base and the COS lies between 0-2.5mm. The buccolingual distance between WALA ridge and FA points (which steadily descends postero-anteriorly) help us determine the shape of the dental archform. The distance is 2.2 mm for 2nd molar & 0.1 mm for the central incisor. Based on the lower arch, the upper arch is coordinated and instituted. To assess the incline of the upper & lower central incisors and roots in the centre of bone, the occlusal plane is evaluated firstly using Andrew's template. Appraisal of Element 1 needs the core discrepancy analysis like crowding. Various deductions decipher the effects that erecting the molars, levelling COS, expansion of maxilla and proclination/ retroclination of incisors will generate on the 'core discrepancy'. All the values will help us deduce the need of extraction/ IPR or expansion. [5,99]

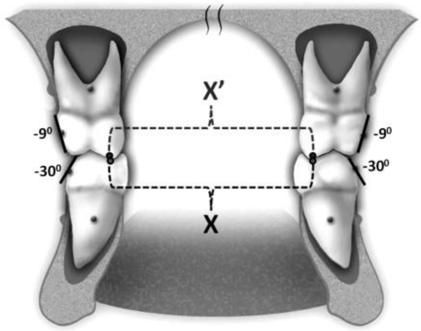


ELEMENT II:

Sagittal jaw position is evaluated by the Element II. Forehead inclination is utilized to devise a landmark called "Goal anterior limit line or GALL". Three types of foreheads are there- straight, round & angular. Superion, Trichion & glabella are demarcated on the basis of on forehead configuration. The distance between FALL (a line through FFA point of forehead which is parallels to plane of forehead) and the DALL (a line through FA point of the central incisor which is parallels to frontal plane of forehead) is clinically recorded. The angle is determined by the forehead inclination relative to the FALL. When forehead inclination is between -7° to + 7°, FALL is equal to GALL. GALL lies 0.6 mm anterior to FALL, for every 24° beyond the range -7° to +7°. When FA point of the upper central incisor lie on the GALL, Element II is said to be optimal. The distance from the central incisor FA point to the GALL is measured and accordingly maxilla is classified as retrognathic (black) or prognathic (red). This enables us to assess the retrognathism/prognathism of the jaws clinically itself and can be used as an adjunct to the regular cephalometric analyses. [5,99]

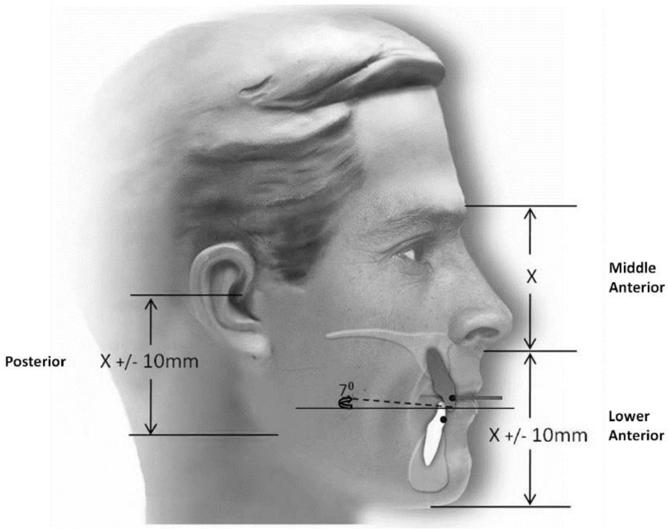
ELEMENT III:

Element III comprises of an appraisal in transverse direction of maxilla relative to the mandible. The cusp to cusp & fossa to fossa distance is gauged. The distance between WALA ridge & FA point of the lower posteriors determines the Element I teeth position & whether uprighting is required for lower posteriors inclined lingually. The aggregate of uprighting is included into fossa-to-fossa transverse lower measurements to give the precise transverse mensuration. [99]



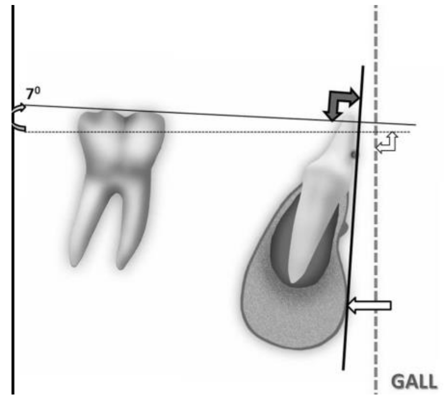
ELEMENT IV:

Element IV is utilized to predict the ‘optimal jaw heights’ supero-inferiorly. While the centric relation is recorded, “the supero-inferior placings of 1st Element upper incisors are harmonious with the lower line of the upper lip at rest, occlusal plane is inclined +2 to +10° in relation to patient in natural head posture, and both the face heights are in range of 10 mm of the middle one, jaws are said to be optimal”.[99]



ELEMENT V:

This deals with the optimal pogonion procumbence sagittaly. It can be defined as “maximal found on pogonion procumbence i.e., on a line which is 90° to occlusal plane which runs through FA point of the 1st Element lower incisor”. The divergence anterior or posterior to this line is noted as +ve or -ve , respectively. [99]



ELEMENT VI:

Element VI is based on the “six keys to optimal occlusion”. It is optimal when all keys are present. Within the 120-study replica the fidelity of features was found: “I) right relationships of arches ; 2) right angulation of crown ; 3) right inclination of crown; 4) no rotations; 5) no spacings contacts; 6) a flat COS”. [99]

The motive of this research was to appraise the relation between WALA ridge and lower posterior teeth intra-orally using Lugol’s solution as a staining agent. To maintain the equal grounds for standardization, Skeletal Class I pattern was included in the study (it was confirmed whether the subjects belonged to Skeletal Class I pattern or not, by the routine lateral cephalograms anyways taken for the further Orthodontic treatment)

Amidst the extraction vs non-extraction controversy, the clinician needs a thorough knowledge of the optimum positions of teeth into the dental and the basal bone ensuring the orofacial harmonious relationships. Although attempts have been made to establish the relation of WALA ridge to mandibular teeth, in vivo studies were not undertaken. And as the WALA ridge is a soft tissue demarcation, studying it on only casts or in vitro is not sufficiently precise. Sample size was computed calculation to obtain the number of sixty-five subjects as per the inclusion & exclusion criteria. [3]

Lugol's solution was applied on the mandibular labial & buccal mucosa, with a cotton pledget till a precise distinction was achieved between attached gingiva & alveolar mucosa and the WALA ridge was appraised. As described by Andrews, WALA ridge was marked on the cast of the same patient by running the pencil parallel to the basal bone. FACC or FA point was demarcated on the coronal portion of the tooth with marking pencil. The distance of all the WALA points to FA points were measured intraorally and were transferred on the mandibular dental casts to form the exact replica of the WALA ridge. The parameters were then measured (& calculated) by digital calliper – WH, WV, Inter-Canine distance in relation to their respective WR & FA points, Inter – molar distance in relation to their respective WR & BA points and DWALA – Difference between actual & normal values of WALA horizontal.

Inter-canine width

After comparing the intercanine width according to WALA points and FA points in Class I skeletal pattern individuals, there was no significant difference between them. It shows that FA and WALA can be used interchangeably for individualizing the archform.

The correlation between WALA ridge and mandibular teeth in Skeletal Class I pattern was found to be moderately positive in Intercanine width. ($p<0.001$).

Inter-molar width

In the comparison of intermolar distance according to WALA and FA points in Class I skeletal pattern, there was no significant difference between them ($p<0.001$). It shows that FA and WALA can be used interchangeably for individualizing the archform.

The correlation between WALA ridge and mandibular teeth in Skeletal Class I pattern was found to be strongly positive in inter-molar width. This shows highly statistically significant correlation ($p<0.001$).

WALA Horizontal

The important goal is when we attempt achieving a proper functional occlusion for the occlusal forces should get channelized along the long axis of the tooth. This is achieved by up-righting molars so that the occlusal planes are in level. Again, there was a positive correlation between WH and posteriors. The results of the study showed that the lesser is the WH, more upright is the tooth.

DWALA

This parameter helped us evaluate the relation for inclination of long axis and DWALA. Moreover, the comparison of DWALA value i.e., the difference between actual and normal values of WALA horizontal at 1st pre molar, 2nd pre molar, 1st molar and 2nd molar by using One sample ‘t’ test value show highly statistically significance between them as the actual/ study values depicting WALA horizontal bilaterally. There is an overall over-estimation of WH values for all the posteriors, for Indian population ($p<0.001$).

According to **Ronay**[1], there is a broad dissimilarity in dental and basal arches which can be attributed to genetics and epigenetic factors which influence the growth and development of the individuals. The estimated archforms are highly unique & are not the variations of a general archform.

However, a significantly positive relation was found in the dental arch and basal arch. Comparisons of LICW and LIMW in Tables 1 & 2 show a persistent statistically significant positive correlation of widths to the respective WALA and FA points. This supports, the “apical base theory”. It might give rise to periodontal problems or unstable post-orthodontic results if dental archform is changed without giving cognizance to the basal arch form. Moreover, clinical archform can be determined by estimating FA values by using WALA values. The studies conducted by **Ronay** et al[1], **Shahroudi** et al[53], **Zou** et al[62], and **Zarate** et al[68] concluded that there is a positive correlation between FA and WALA points as proved in the present study. The hypothesis is also supported by **Glass** et al[76], **Shrestha** et al[80], **Kato** and **Arai**[85]. However, few authors differed viz. **Wonglamsam** et al[43] who found no correlation between faciolingual widths of basal bone. **Lombardo**[64] questioned over the fact of using lower apical base as a reference for ideal dental arch. **Lima** et al[78] found WALA to be unstable landmark. Hence, the present study aimed to enlighten this aspect too.

A functional appliance caused significant amount of transverse expansion of maxilla. Meanwhile a study by **Oda** et al[86] proved dehiscence or buccal cortex after palatal expansion when observed by using CT scans.[87,12] It is claimed by the recent bone-growing theorists: crowded posteriors can be displaced transversely, & buccal cortices are remodelled with no tip movement and bone loss with very light forces. But orthodontists have faith that the arches cannot be expanded very rapidly without usage of heavier forces like maxillary expansion. Thus, this conundrum remains unresolved. Thorough knowledge of the morphological structure of the supporting periodontium after old school and recent mechanics of Orthodontics and treatment stability is very crucial, and the FA & WALA points delineated in this research might prove useful credentials for this. [1,12]

The results are clinically very relevant in demonstrating the ability to observe the basal bone structure and predict an individual dental archform. The WALA-FA relationships should be different in skeletal & dental Class II & III relationships, as well as in adults relative to growing patients. **Ball** et al [48] studied the Correlation in WALA and FA points in Class II div 1 also, and found a positive correlation. **Gupta** et al [49] also reconfirmed the same. **Shu** et al [56] compared the correlation in Class I and II individuals and got that Buccolingual inclination is an important factor in Class II discrepancies more than alveolar breadth or arch width. Furthermore, **Suk** et al [57] found the correlation in Class III subjects but found weak correlation as compared to that of Class I. Contradictorily, **Suzuki** et al [70] founded positive correlation in Class III. Hence, this gives the scope for further research.

This research also demonstrates that in posteriors, FA points are far lingual than the WALA points which can be associated with the observed rise of crown torque along the dental arches keeping in mind that the dental and basal bases have different shape. This finding relates with that of Andrews and Andrews who obtained positive values of points FA and WALA which were consistently placed far buccal than the most protuberant point of crown. **McNamara** [46] pointed out that there is no method to determine ideal archform which was reinforced by **Fonseca** et al. [61] Then many authors like **Rick-o-Neil** [82]**, Weaver** et al [3] and **Lombardo** et al [55] said that WALA plays vital role in fabricating the ideal archform for the individual. Furthermore, **Lombardo** et al [64] said that pre formed archwires do not account the Ethnic heterogeneity. Also, **Yazeed** et al [59] focussed that there are ethnic differences and different norms for Egyptians. The results of the present study comply with their results, as in Indian population WH normal values are overestimated that depict the buccolingual inclination differences persist in comparison to Caucasian norms.

Thus, the findings embrace the hypothesis that WALA points describe the basal arch and dental arch can be formed accordingly. This study also supports the study by **Ronay** et al [1] who suggested that basal and dental arches should be derived individually. Also, the ridge obtained by joining WALA points can be utilized as a reference or a template for deriving the dental arch which remains unique to that particular patient. If all these factors will be taken care of, we can ensure the orofacial harmony and sound periodontal structures.

LIMITATIONS

- CBCT sections could have been used for precise measurements. In this study, they are not used as it was not indicated in the routine dental records.
- Electronic scanning of dental cast could have been used for more accurate measurements. Due to its non-availability in the vicinity, it could not be done.

SUMMARY & CONCLUSION

The derivations of arch forms from FA and WALA are unique but are correlated. The results show that configuration, level of curvature, and various specifications of the alveolar bone and arches are bound to have disparity. The predetermination of a dental arch form can be done by WALA demarcations, but slightly over-estimates it may be because of the norms that are given for Caucasian population. The high significant correlation of WALA points and FA points distances in the canine and molar regions shows that computation of points of WALA ridge help us predict the symbolizing the FA estimates and the present arch form. This ensures individualized treatment and better Orofacial harmony.

Following conclusions can be drawn:

1. WALA ridge can be successfully appraised intra-orally.

2. FA points of all the mandibular posteriors have highly statistically significant correlation with their respective WALA points, except that of intercanine width which shows moderately statistically significant correlation.

3. Either of the two points (FA/WALA) can be used for determination of ideal archform for the particular individual.

4. The normal values of WH are over-estimated for Indian population & need to be revised.

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TABLES & GRAPHS

The descriptive results have been tabulated in all the following tables:

Table 1: Comparison of inter - canine width according to WALA ridge (WALA points) andmandibular teeth (FA points) in skeletal Class I pattern

Inter canine width	Mean	SD	Unpaired t test	p value, Significance
FA points	**24.88**	**1.36**	**t = -8.112**	**p< 0.001****
WALA points	**26.88**	**1.44**		

p>0.05 – no significant difference ***p<0.001- significant difference**

Table 2: Comparison of inter - molar distance according to WALA ridge (WALA points) and mandibular teeth (FA points) in skeletal Class I pattern

Inter molar distance	Mean	SD	Unpaired t test	P value, Significance
FA points	**51.34**	**1.59**	**t = -7.673**	**p<0.001****
WALA points	**53.3**	**1.3**		

p>0.05 – no significant difference ***p<0.001- significant difference**

Table 3: Correlation between WALA ridge and mandibular teeth in skeletal Class I pattern

	Parameters	Pearson 'r' correlation coefficient	p value, Significance
Inter-canine width	**FA points x WALA points**	**r = 0.466** **(Moderate positive correlation)**	**p<0.001** (Highly significant)**
Inter molar width	**FA points x WALA points**	**r = 0.687** **(Strong positive correlation)**	**p<0.001** (Highly significant)**

****p<0.001 – highly statistical significant correlation**

Table 4: Comparison of DWALA value i.e., difference between actual study and normalvalues of WALA horizontal at 1st premolar

1st premolar	Actual study WALA Horizontal Mean (SD)	Normal values 1st premolar WALA Horizontal Mean (SD)	One sample 't' test value	P value, Significance
Left	**1.27 (0.46)**	**0.8 (0.0)**	**t = 8.125**	**p<0.001****
Right	**1.36 (0.38)**	**0.8 (0.0)**	**t = 11.761**	**p<0.001****

****p<0.001 – highly statistical significant difference**

Table 5: Comparison of DWALA value i.e., difference between actual study and normalvalues of WALA horizontal at 2nd premolar

2nd premolar	Actual study WALA Horizontal Mean (SD)	Normal values2nd premolar WALA Horizontal Mean (SD)	One sample 't' test value	P value, Significance
Left	**2.31 (0.54)**	**1.3 (0.0)**	**t = 14.871**	**p<0.001****
Right	**2.43 (0.46)**	**1.3 (0.0)**	**t = 19.595**	**p<0.001****

****p<0.001 – highly statistical significant difference**

Table 6: Comparison of DWALA value i.e., difference between actual study and normalvalues of WALA horizontal at 1st molar

1st molar	Actual study WALA Horizontal Mean (SD)	Normal values 1st molar WALA Horizontal Mean (SD)	One sample 't' test value	P value, Significance
Left	**2.54 (0.37)**	**2.0 (0.0)**	**t = 11.476**	**p<0.001****
Right	**2.66 (0.36)**	**2.0 (0.0)**	**t = 11.735**	**p<0.001****

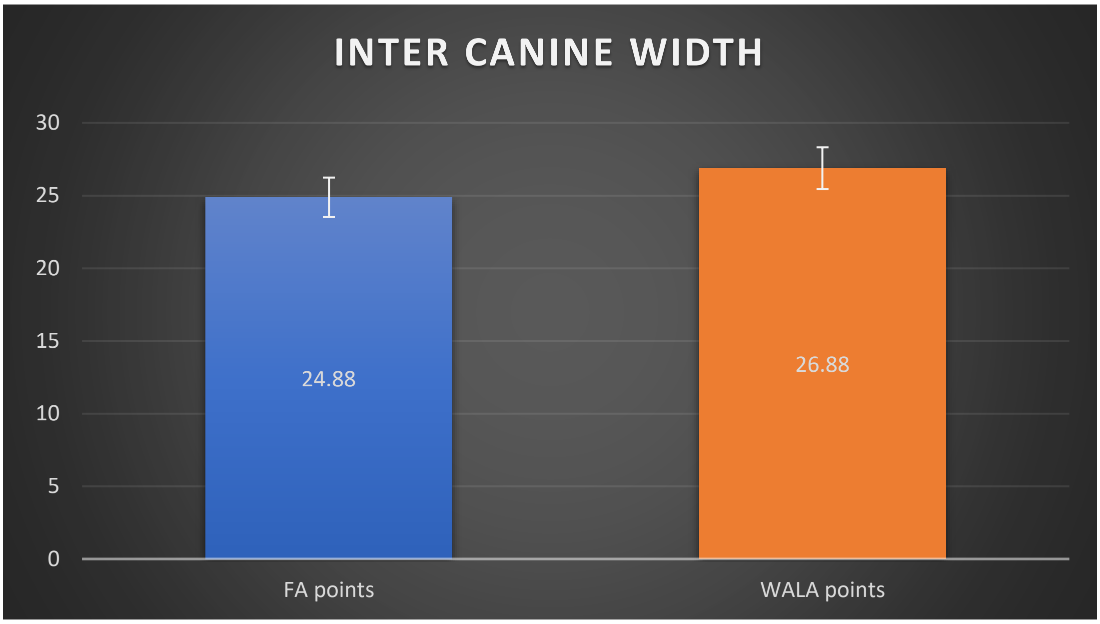
****p<0.001 – highly statistical significant difference**

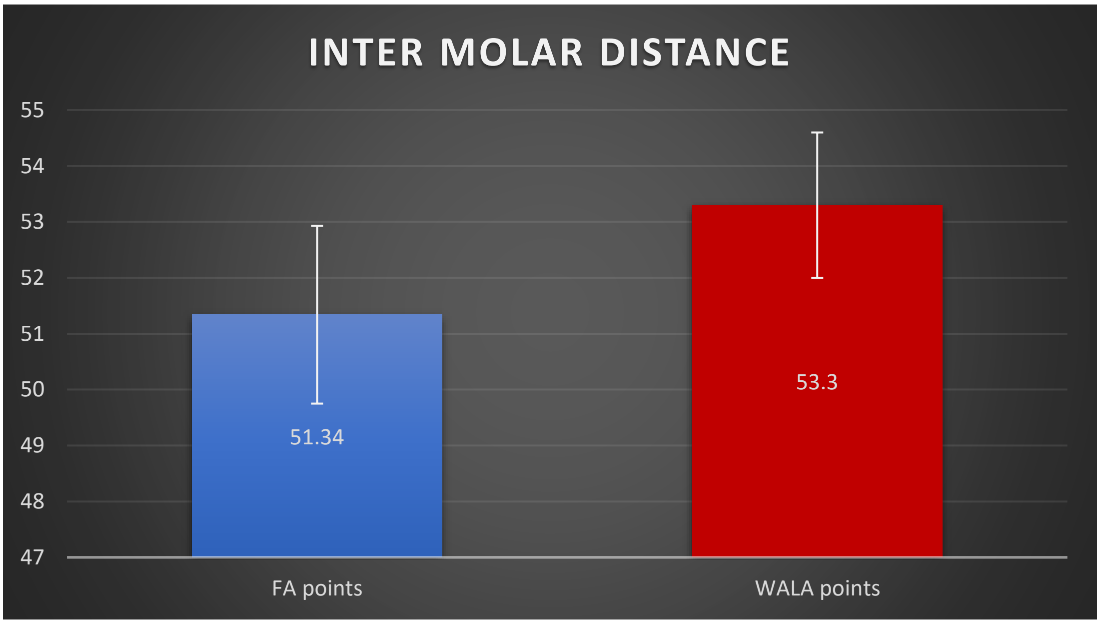
Table 7: Comparison of DWALA value i.e., difference between actual study and normalvalues of WALA horizontal at 2nd molar

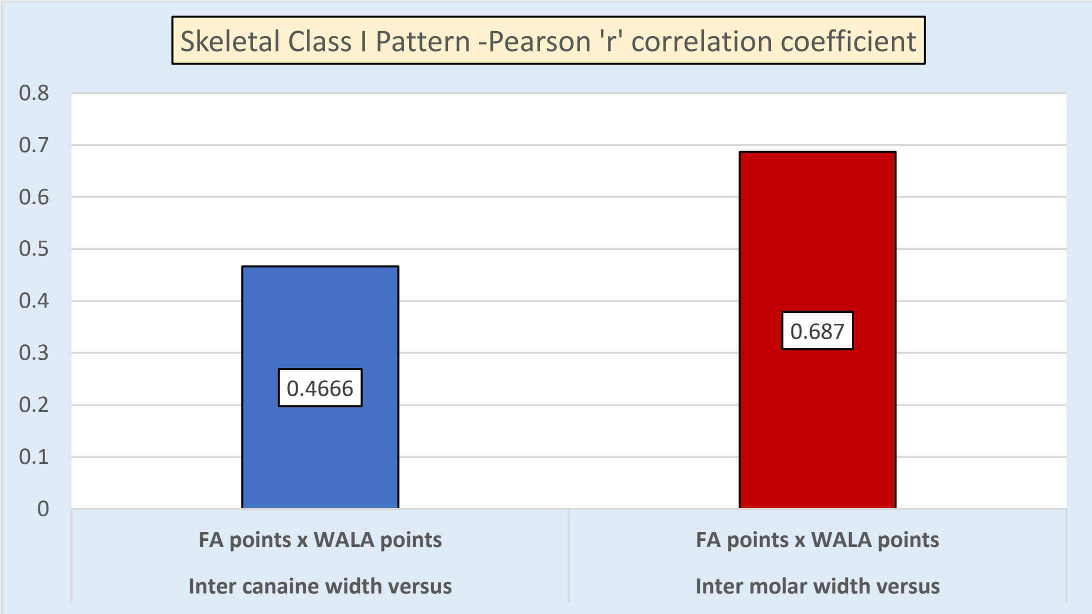
2nd Molar	Actual study WALA Horizontal Mean (SD)	Normal values2nd molar WALA Horizontal Mean (SD)	One sample 't' test value	P value, Significance
Left	**3.62 (0.45)**	**2.2 (0.0)**	**t = 25.442**	**p<0.001****
Right	**3.71 (0.44)**	**2.2 (0.0)**	**t = 27.297**	**p<0.001****

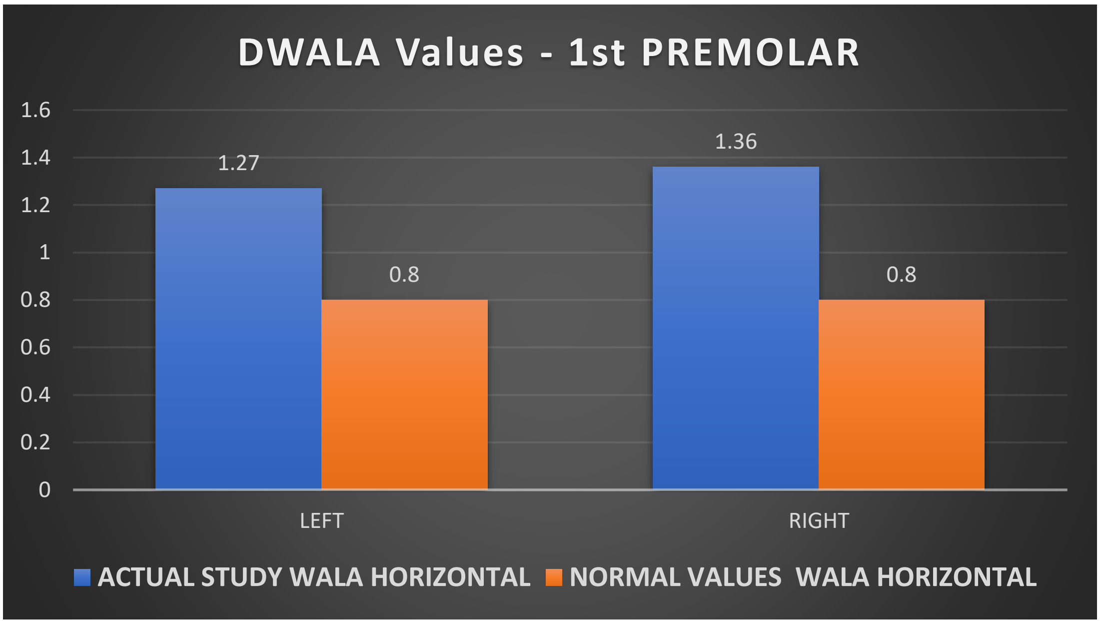
****p<0.001 – highly statistical significant difference**

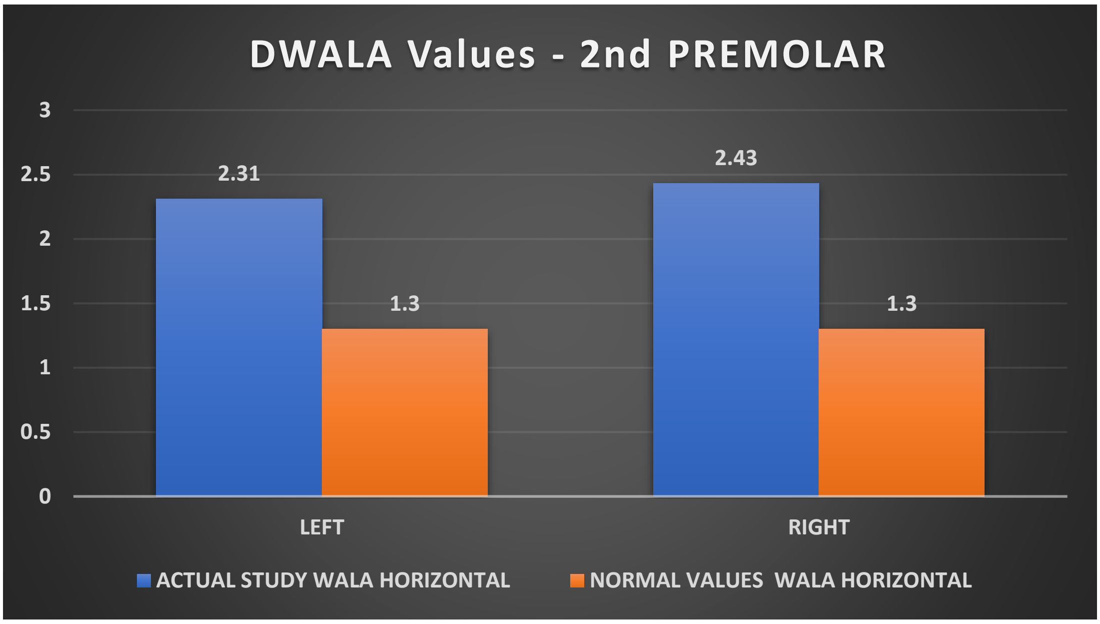
The descriptive results have been graphically represented as follows:

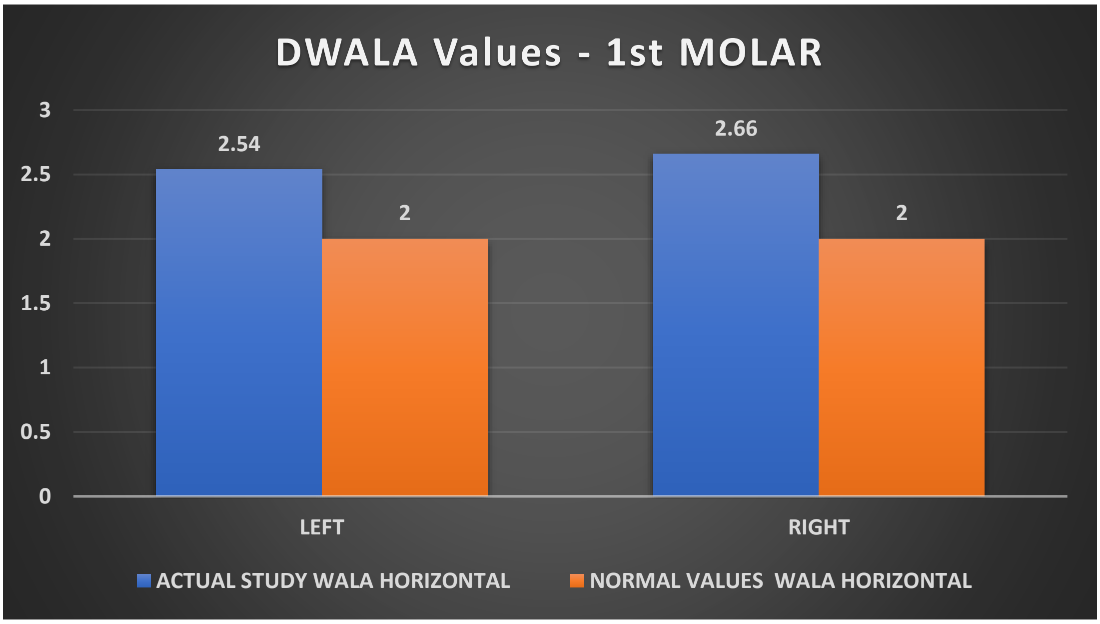


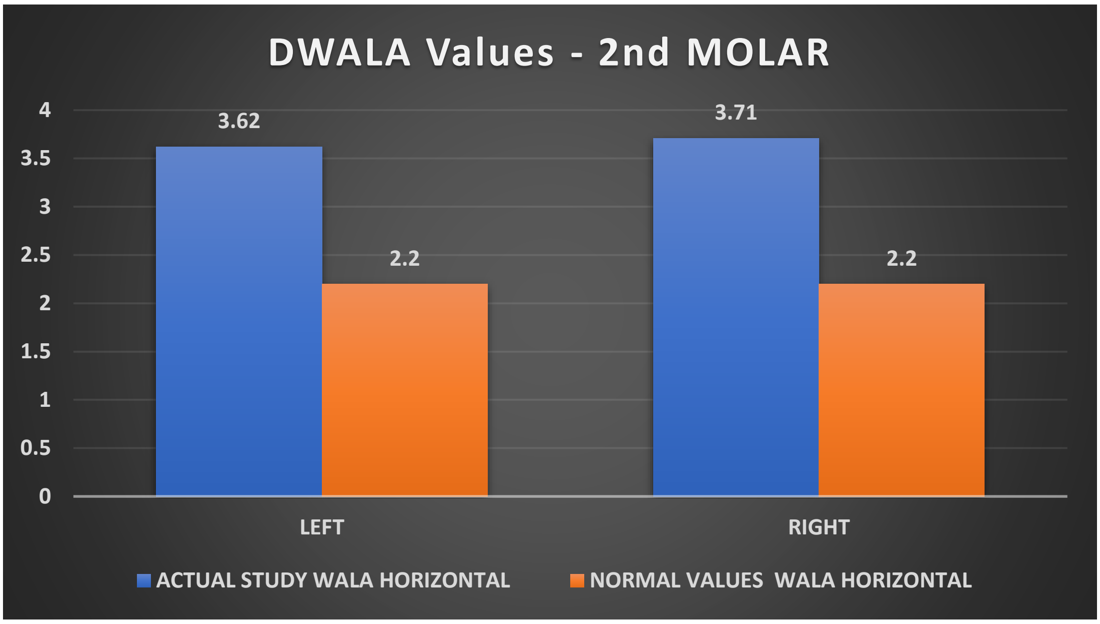



Skeletal Class I Pattern -Pearson 'r' correlation coefficient
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.4666
0.687
FA points x WALA points
Inter canaine width versus
FA points x WALA points
Inter molar width versus


DWALA Values - 1st PREMOLAR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.27
0.8
1.36
0.8
LEFT
RIGHT
ACTUAL STUDY WALA HORIZONTAL
NORMAL VALUES WALA HORIZONTAL


DWALA Values - 2nd PREMOLAR
3
2.5
2
1.5
1
0.5
0
2.31
1.3
2.43
1.3
LEFT
RIGHT
ACTUAL STUDY WALA HORIZONTAL
NORMAL VALUES WALA HORIZONTAL


DWALA Values - 1st MOLAR
3
2.5
2
1.5
1
0.5
0
2.54
2
2.66
2
LEFT
RIGHT
ACTUAL STUDY WALA HORIZONTAL
NORMAL VALUES WALA HORIZONTAL


DWALA Values - 2nd MOLAR
4
3.5
3
2.5
2
1.5
1
0.5
0
3.62
2.2
3.71
2.2
LEFT
RIGHT
ACTUAL STUDY WALA HORIZONTAL
NORMAL VALUES WALA HORIZONTAL

ANNEXURE I

CASE RECORD FORM:

Date:

NAME: AGE/ SEX:

ADDRESS:

CONTACT NUMBER: OPD NUMBER:

Chief Complaint:

Past medical & dental history:

CLINICAL EXAMINATION:

- EXTRAORAL EXAMINATION:

  Facial profile etc:

- INTRAORAL EXAMINATION:

  Teeth present:

  Teeth in occlusion:

  Molar & canine relation:

WALA to FA points distance in mm :

Tooth type	1st pre molar	2nd pre molar	1st molar	2nd molar
Left side				
Right side				

WH values in mm :

Tooth type	1st pre molar	2nd pre molar	1st molar	2nd molar
Left side				
Right side				

IM

width in mm : FA-

WALA-

IC width in mm : FA-

WALA-

DWALA values in mm :

Tooth type	1st pre molar	2nd pre molar	1st molar	2nd molar
Left side				
Right side				

Staff signature

ANNEXURE II

(गोपनीय)

माहितीपूर्ण संमती फॉर्म

"AN IN VIVO EVALUATION OF THE RELATIONSHIP BETWEEN WALA RIDGE AND MANDIBULAR TEETH IN SKELETAL CLASS I PATTERN"

नाव: श्री/चि./श्रीमती/कु. .____

निवासी: ____

वय___________वर्ष. माझ्या इच्छेच्या / निवडीचा कोणत्याही स्वरूपाचा कोणताही दबाव / प्रोत्साहन न लावता, याद्वारे डॉ. ____________________________________ ने प्रकल्पाचे आयोजन करण्याची माझी मंजुरी देतो/ देते. मी "रुग्णाच्या माहिती पत्रकाची" पावती स्वीकारत आहे आणि डॉक्टरांनी मला या संशोधन प्रकल्पाबद्दल योग्य आणि सूचने बद्दल माहिती दिली आहे. मी माझ्या मौखिक पोकळीत lugol's solution आणि digital caliper वापर करण्याची अधिकृती देतो/ देते .मी माझ्या एक्स-रे, छायाचित्रे, आवश्यकतेनुसार इतर तपासण्या करण्यास सहमत आहे.

मी या प्रकल्पात भाग घेण्यास सहमती देतो आणि या चाचणीच्या काळात कोणतीही इतर योजना एकत्रित करणार नाही. मी डेन्टल हॉस्पिटल मध्ये किंवा इतर ठिकाणी दिलेल्या नियोजित तारखा आणि वेळांचे पालनकरीन.

मी प्रमाणित करतो की मी या फॉर्म ची माहीती वाचलेली आहे किंवा कोणाकडून वाचवून घेतली आहे. ____दिनांक________

__________________रुग्ण / कायदेशीर पणे अधिकृत प्रतिनिधी

स्वाक्षरी

(Confidential)

Informed Consent Form

"AN IN VIVO EVALUATION OF THE RELATIONSHIP BETWEEN WALA RIDGE AND MANDIBULAR TEETH IN SKELETAL CLASS I PATTERN"

NAME: Mr./Master/Mrs./Miss.____

Resident of: ____

___________________________________aged _____ years, exercising my free will/choice, without any pressure/lure of incentive in any form, hereby give my consent for the project to be conducted by **Dr. ______________________________.**

I acknowledge the receipt of "patient's information sheet", and also the doctor has informed me about this research project suitably and sufficiently to my satisfaction.

I agree to undergo this procedure and allow use of Lugol's solution & digital caliper as a part of the study.

I agree to let my X-rays, photographs, other investigations to be taken as required.

I agree to take part in this project and will not mix any other projects during the period of this trial. I shall report to the dental hospital or other place where called on given appointment dates and time.

I certify that I have read or had read to me the contents of this form.

____

_________Date ____________________________

Patient /legally authorized representative signature

INFORMED CONSENT FORM

"AN IN VIVO EVALUATION OF THE RELATIONSHIP BETWEEN WALA RIDGE AND MANDIBULAR TEETH IN SKELETAL CLASS I PATTERN"

वैयक्तीक माहिती

रूग्णाचे नाव : दिनांक :
वय/लिंग :
पत्ता :

मोबाईल नंबर :

मी कबूल करतो की डॉक्टरांनी मला या संशोधन प्रकल्पाबद्दल समाधानकारक माहिती दिली आहे. मी माझ्या एक्स-रे, छायाचित्रे, इंप्रेशन आणि आवश्यकतेनुसार अन्य तपासण्या करण्यास सहमत आहे. मी या प्रकल्पात भाग घेण्यास सहमती देतो आणि या चाचणीच्या कालावधीत कोणतेही अन्य प्रकल्प एकत्रित करणार नाही. मला डेन्टल हॉस्पिटल किंवा इतर ठिकाणी दिलेल्या भेटीची तारीख आणि वेळ सांगितली आहे. मी डॉक्टर आणि पॅरामेडिकल कर्मचा-यांना सर्व बाबतीत सहकार्य करेल. या अभ्यासात मी माझ्या सहभागाचे निकाल प्रकाशित करण्यास परवानगी देतो. मला कोणतीही नुकसान भरपाई दिली जाणार नाही. असे करण्यासाठी कोणतेही कारण न देता मला कोणत्याही वेळी या संशोधन प्रकल्पातून बाहेर पडण्याचा अधिकार मिळालेला आहे. मी या अन्वये केलेल्या चाचणीत सहभागासाठी माझी संमती नोंदवित आहे.

________	________	________	________
१) रूग्णाचे नाव	स्वाक्षरी	तारीख	वेळ
________	________	________	________
२) साक्षीदाराचे नाव	स्वाक्षरी	तारीख	वेळ
________	________	________	________
३) डॉक्टरचे नाव	स्वाक्षरी	तारीख	वेळ

ANNEXURE III
MASTER CHART

MEAN INTER-CANINE DISTANCE ACCORDING TO FA AND WALA POINTS

Sr.no.	Inter-canine width (mm)	
	Relative to FA points	Relative to WALA points
1.	26.5	27.3
2.	25.6	28.4
3.	26	29
4.	25	26
5.	23	28.9
6.	25.5	25.6
7.	24	28
8.	23	27.3
9.	26.7	28.4
10.	24.2	25.3
11.	24.8	26.7
12.	25.7	28.3
13.	25.8	29.5
14.	24.8	25.1
15.	23	29.3
16.	24.3	25.7
17.	26.3	28.4

18.	26.2	26.4
19.	24	25
20.	23.8	25.3
21.	23	24.4
22.	24	27.5
23.	25.9	29.4
24.	25	25
25.	24.1	26.3
26.	27.2	29
27.	25	26
28.	26.4	27.4
29.	27.7	28.75
30.	24	25.2
31.	27	27.3
32.	24.8	28
33.	26.1	26.3
34.	27.3	27.4
35.	24.8	28.4
36.	24.5	28.3
37.	25.5	26.7
38.	25	25.3
39.	26.2	27.9
40.	26.4	28.1
41.	23.2	27.3

42.	26.2	28
43.	22.9	27.1
44.	23.7	26.5
45.	23.6	25.6
46.	24.6	26.4
47.	24.9	27
48.	25	25.2
49.	27	27.4
50.	26.3	28.8
51.	23.56	24.6
52.	26.3	26.3
53.	23.7	27.5
54.	27.3	28.6
55.	25.4	27.3
56.	25.3	26
57.	22.6	23.5
58.	23.4	26
59.	24.3	25.8
60.	23.1	25.4
61.	22.7	27
62.	22.9	24.5
63.	23.6	27.3
64.	23.8	26.8
65.	24.1	24.9

MEAN INTER-MOLAR DISTANCE ACCORDING TO FA AND WALA POINTS

Sr.no.	Inter-molar width (mm)	
	Relative to FA points	Relative to WALA points
1.	52	52.4
2.	54.3	55.2
3.	49.8	52.1
4.	49.2	51.9
5.	48	50.7
6.	50.6	54.4
7.	52.5	53
8.	49	51.7
9.	52	53.2
10.	51.5	52.2
11.	49.7	51.6
12.	53.9	54.7
13.	52.8	53.2
14.	49.1	51.4
15.	51.8	53.2
16.	48.7	51.5
17.	51.3	53.9
18.	52.5	53.7
19.	50.4	54
20.	48	52.7
21.	51.6	53.5
22.	52	53.4
23.	51	52.4
24.	49.4	52.13
25.	53.8	55.1
26.	51.3	52.9
27.	52	52.3
28.	51	55.1
29.	48.8	52.2
30.	52	52.1
31.	52.2	55.1
32.	52	53.7

33.	50.9	53.8
34.	52.6	52.8
35.	51.8	54
36.	51.7	54.6
37.	53.2	55
38.	52.25	54.4
39.	51.9	55
40.	52.6	53
41.	53.2	54.2
42.	50	51.6
43.	52.8	55.1
44.	50.7	51.7
45.	51	52.5
46.	51.6	53
47.	49.5	52.5
48.	51.4	54.1
49.	53.6	53.6
50.	52.6	55.8
51.	51.4	52.4
52.	51.7	54.1
53.	48.9	52.4
54.	51.3	53
55.	52.6	53.5
56.	51	52.6
57.	47.9	50
58.	54.4	54.8
59.	51.7	52.9
60.	51	55.1
61.	49.3	52
62.	52.6	53.6
63.	49.8	55.2
64.	54.1	56
65.	52.1	53.9

WALA HORIZONTAL MEASUREMENTS AND THE RESPECTIVE DWALA VALUES FOR 1st PRE-MOLAR

(Given value = 0.8 mm)

Sr.no.	WH values (mm)		DWALA Values (mm)	
	Left side	Right side	Left side	Right side
1.	2.4	1.8	1.6	1
2.	0.36	1.23	-0.44	0.43
3.	1.8	1.3	1	0.5
4.	1.22	1.38	0.42	0.58
5.	0.82	1.02	0.02	0.22
6.	0.63	0.93	-0.17	0.13
7.	1.37	1.63	0.57	0.83
8.	0.79	0.83	-0.01	0.03
9.	1.63	1.93	0.83	1.13
10.	1.13	0.79	0.33	-0.01
11.	1.64	1.88	0.84	1.08
12.	2	1.93	1.2	1.13
13.	1.02	1.05	0.22	0.25
14.	1.62	1.45	0.82	0.65
15.	0.36	0.84	-0.44	0.04
16.	1.53	1.65	0.73	0.85
17.	1.8	1.34	1	0.54
18.	1.63	1.93	0.83	1.13
19.	1.53	1.47	0.73	0.67
20.	0.79	0.94	-0.01	0.14
21.	1.4	1.53	0.6	0.73
22.	0.83	0.99	0.03	0.19
23.	1.13	1.3	0.33	0.5
24.	1.95	1.28	1.15	0.48
25.	1.66	1.39	0.86	0.59
26.	0.98	0.91	0.18	0.11
27.	2	1.89	1.2	1.09
28.	1.46	1.39	0.66	0.59
29.	1.03	1.39	0.23	0.59
30.	1.74	1.59	0.94	0.79

31.	1.32	1.55	0.52	0.75
32.	0.73	0.82	-0.07	0.02
33.	1.63	1.83	0.83	1.03
34.	1.52	1.38	0.72	0.58
35.	1.08	1.74	0.28	0.94
36.	1.23	1.37	0.43	0.57
37.	1.44	1.83	0.64	1.03
38.	1.21	1.73	0.41	0.93
39.	0.93	0.68	0.13	-0.12
40.	1.54	1.37	0.73	0.57
41.	1.43	1.63	0.63	0.83
42.	1.64	1.73	0.84	0.93
43.	0.98	1.03	0.18	0.23
44.	0.85	1.49	0.05	0.69
45.	2.01	1.89	1.21	1.09
46.	1.63	1.38	0.83	0.58
47.	1.13	1.36	0.33	0.56
48.	1.42	1.33	0.62	0.53
49.	0.84	0.82	0.04	0.02
50.	0.57	0.97	-0.23	0.17
51.	2.06	1.79	1.26	0.99
52.	1.92	2.02	1.12	1.22
53.	0.87	1.02	0.07	0.22
54.	1.48	1.73	0.68	0.93
55.	1.12	1.83	0.32	1.03
56.	0.48	1.42	-0.32	0.62
57.	1.09	1.63	0.29	0.83
58.	1.32	1.18	0.52	0.38
59.	1.63	1.37	0.83	0.57
60.	0.58	0.89	-0.22	0.09
61.	1.52	1.36	0.72	0.56
62.	0.59	0.38	-0.21	-0.42
63.	0.62	0.82	-0.18	0.02
64.	1.49	1.39	0.69	0.59
65.	0.63	0.72	-0.17	-0.08

WALA HORIZONTAL MEASUREMENTS AND THE RESPECTIVE DWALA VALUES FOR 2nd PRE-MOLAR

(Given value = 1.3 mm)

Sr.no.	WH values (mm)		DWALA Values (mm)	
	Left side	Right side	Left side	Right side
1.	2.43	2.32	1.13	1.02
2.	2.32	2.53	1.02	1.23
3.	2.58	2.43	1.28	1.13
4.	2.43	2.56	1.13	1.26
5.	3.59	3.29	2.29	1.99
6.	3.24	3.19	1.94	1.89
7.	3	2.89	1.7	1.59
8.	1.94	1.94	0.64	0.64
9.	2.49	2.4	1.19	1.1
10.	2.43	2.49	1.13	1.19
11.	3.2	3.24	1.9	1.94
12.	1.93	1.92	0.63	0.62
13.	2.39	2.83	1.09	1.53
14.	1.89	1.94	0.59	0.64
15.	2.02	2.03	0.72	0.73
16.	2.4	3.01	1.1	1.71
17.	2.92	2.49	1.62	1.19
18.	1.04	2.14	-0.26	0.84
19.	2.19	2.11	0.89	0.81
20.	2.2	2.18	0.9	0.88
21.	2.1	2.11	0.8	0.81
22.	2.03	2.3	0.73	1
23.	2	2.19	0.7	0.89
24.	1.49	2.28	0.19	0.98
25.	3.02	3.17	1.72	1.87
26.	2.19	2.39	0.89	1.09
27.	3.1	3.23	1.8	1.93
28.	2.45	2.4	1.15	1.1
29.	1.04	1.93	-0.26	0.63
30.	1.45	2.24	0.15	0.94

31.	2.3	3.01	1	1.71
32.	1.94	2.34	0.64	1.04
33.	1.35	1.42	0.05	0.12
34.	2.43	2.43	1.13	1.13
35.	2.33	2.43	1.03	1.13
36.	2.19	2.43	0.89	1.13
37.	1.49	1.93	0.19	0.63
38.	1.32	1.55	0.02	0.25
39.	1.43	1.45	0.13	0.15
40.	2.4	2.22	1.1	0.92
41.	2.3	2.6	1	1.3
42.	1.39	1.45	0.09	0.15
43.	3.2	3.5	1.9	2.2
44.	2.44	2.5	1.14	1.2
45.	1.99	2	0.69	0.7
46.	2.53	3.01	1.23	1.71
47.	2.5	2.37	1.2	1.07
48.	2.64	2.53	1.34	1.23
49.	3	3.2	1.7	1.9
50.	2.01	2.38	0.71	1.08
51.	2.53	2.14	1.23	0.84
52.	2.34	2.42	1.04	1.12
53.	2.5	2.34	1.2	1.04
54.	2.83	2.84	1.53	1.54
55.	1.96	2	0.66	0.7
56.	2.15	2.19	0.85	0.89
57.	2.53	2.46	1.23	1.16
58.	3.05	2.98	1.75	1.68
59.	2.42	2.36	1.12	1.06
60.	2.2	2.2	0.9	0.9
61.	2.14	2.19	0.84	0.89
62.	2.5	2.5	1.2	1.2
63.	3.3	3.2	2	1.9
64.	2.6	2.8	0.7	1.5
65.	2.45	2.7	1.15	1.4

WALA HORIZONTAL MEASUREMENTS AND THE RESPECTIVE DWALA VALUES FOR 1st MOLAR

(Given value = 2 mm)

Sr.no.	WH values (mm)		DWALA Values (mm)	
	Left side	Right side	Left side	Right side
1.	2.52	3.26	0.52	1.26
2.	2.38	2.65	0.38	0.65
3.	2.19	2.31	0.19	0.31
4.	3.1	2.63	1.1	0.63
5.	3.18	2.87	1.18	0.87
6.	2.42	2.46	0.42	0.46
7.	1.98	2.02	-0.02	0.02
8.	2.8	2.75	0.8	0.75
9.	2.13	2.4	0.13	0.4
10.	2.99	3.2	0.99	1.2
11.	3.18	3.5	1.18	1.5
12.	2.48	2.6	0.48	0.6
13.	2.49	2.5	0.49	0.5
14.	2.94	3.42	0.94	1.42
15.	2.88	3.02	0.88	1.02
16.	2.43	2.64	0.43	0.64
17.	1.48	2.55	-0.52	0.55
18.	2.33	2.45	0.33	0.45
19.	2.83	2.95	0.83	0.95
20.	2.19	2.43	0.19	0.43
21.	3.01	3.29	1.01	1.29
22.	2.47	3.02	0.47	1.02
23.	2.94	2.94	0.94	0.94
24.	2.24	2.52	0.24	0.52
25.	3.18	3.18	1.18	1.18
26.	2.11	2.15	0.11	0.15
27.	2.46	2.6	0.46	0.6
28.	2.53	2.48	0.53	0.48
29.	2.43	2.43	0.43	0.43
30.	2.68	2.67	0.68	0.67

31.	2.77	2.9	0.77	0.9
32.	2.15	2.2	0.15	0.2
33.	2.44	2.7	0.44	0.7
34.	1.98	2.28	-0.02	0.28
35.	1.44	2	-0.56	0
36.	2.18	2.14	0.18	0.14
37.	2.21	2.13	0.21	0.13
38.	2.4	2.5	0.4	0
39.	2.77	3.1	0.77	1.1
40.	2.17	2.53	0.17	0.53
41.	2.85	3	0.85	1
42.	2.63	2.86	0.63	0.86
43.	2.64	2.55	0.64	0.55
44.	1.99	2	-0.01	0
45.	2.54	2.74	0.54	0.74
46.	2.46	2.5	0.46	0.5
47.	2.76	2.55	0.76	0.55
48.	2.14	2.14	0.14	0.14
49.	2.87	2.66	0.87	0.66
50.	3.15	3.2	1.15	1.2
51.	2.75	2.8	0.75	0.8
52.	2.53	2.64	0.53	0.64
53.	2.73	2.4	0.73	0.4
54.	2.88	3.5	0.88	1.5
55.	2.42	2.6	0.42	0.6
56.	2.67	2.6	0.67	0.6
57.	3.29	3.24	1.29	1.24
58.	2.53	2.6	0.53	0.6
59.	2.55	2.55	0.55	0.55
60.	2.52	2.52	0.52	0.52
61.	2.85	2.87	0.855	0.87
62.	2.65	2.56	0.65	0.56
63.	2.66	2.43	0.66	0.43
64.	2.42	2.42	0.42	0.42
65.	2.14	2.87	0.14	0.87

WALA HORIZONTAL MEASUREMENTS AND THE RESPECTIVE DWALA VALUES FOR 2nd MOLAR

(Given value = 2.2 mm)

Sr.no.	WH values (mm)		DWALA Values (mm)	
	Left side	Right side	Left side	Right side
1.	3.76	3.65	1.56	1.45
2.	3.66	3.79	1.46	1.59
3.	3.95	3.99	1.75	1.79
4.	3	3.2	0.8	1
5.	2.67	2.89	0.47	0.69
6.	3.85	3.43	1.65	1.23
7.	3.65	3.5	1.45	1.3
8.	3.55	3.55	1.35	1.35
9.	2.54	2.54	0.34	0.34
10.	3.76	3.76	1.56	1.56
11.	3.95	3.97	1.75	1.77
12.	3.55	3.55	1.35	1.35
13.	3.27	3.54	1.07	1.34
14.	3.66	3.68	1.46	1.48
15.	3.28	3.3	1.08	1.1
16.	2.98	2.99	0.78	0.79
17.	4.2	4.3	2	2.1
18.	3.86	3.5	1.66	1.3
19.	3.09	3.9	0.89	1.7
20.	3.89	3.54	1.69	1.34
21.	4	4.2	1.8	2
22.	3.76	3.89	1.56	1.69
23.	3.57	3.67	1.37	1.47
24.	3.27	3.87	1.07	1.67
25.	3.97	3.9	1.77	1.7
26.	4.27	4.28	2.07	2.98
27.	4.3	3.98	2.1	1.78
28.	3.67	3.67	1.47	1.47
29.	3.26	4.67	1.06	2.47
30.	3.68	3.67	1.48	1.47

31.	4.48	4.32	2.28	2.12
32.	4.68	3.64	2.48	1.44
33.	2.99	3.3	0.79	1.1
34.	3.75	4.32	1.55	2.12
35.	3.97	4.35	1.77	2.1
36.	3.56	3.53	1.36	1.33
37.	3.22	3.22	1.02	1.02
38.	3.64	3.56	1.44	1.36
39.	3.37	3.94	1.17	1.74
40.	3.57	3.56	1.37	1.36
41.	3.18	3.39	0.98	1.19
42.	3.96	4.38	1.76	2.18
43.	3.57	3.57	1.37	1.37
44.	4.09	4.29	1.89	2.09
45.	2.89	3.49	0.69	1.29
46.	4.29	4.38	2.09	2.18
47.	3.33	3.59	1.13	1.39
48.	4.29	4.33	2.09	2.13
49.	3.95	3.93	1.75	1.73
50.	2.79	3.64	0.59	1.44
51.	3.95	3.05	1.75	0.85
52.	3.57	4.39	1.37	2.19
53.	4.1	4.02	1.9	1.82
54.	3.75	3.75	1.55	1.55
55.	3.26	4.32	1.06	2.12
56.	3.87	4.22	1.67	2.02
57.	3.26	3.2	1.06	1
58.	3.9	3.11	1.7	0.91
59.	3.59	3.29	1.39	1.09
60.	3.22	3.26	1.02	1.06
61.	3.86	3.56	1.66	1.36
62.	3.97	3.55	1.77	1.35
63.	3.64	4.24	1.44	2.04
64.	3.19	3.24	0.99	1.04
65.	2.83	2.96	0.63	0.76