Description of the WALA edge measured in STL and DICOM files.

Manuel Estuardo Bravo Calderón[1], Marco Vinicio Bernal Pinos[2], Mauricio Rubén Zhingre Suárez[3]

Abstract

The objective of this study was to describe the WALA edge, using STL and DICOM files, contrasting the results with the values given by the authors Will Andrews and Larry Andrews and thus which diagnostic method is the closest to reality.This descriptive observational study included 36 participants, ranging in age from 23 to 33 years, university students, who underwent CBCT computed tomography studies (DICOM files) and intraoral scans to obtain STL models. Two Meshmixer software were used for the STL and 3D Slicer for the CBCT.In both diagnostic methods, for the measurement of the WALA edge, the following was determined: the point of the facial axis (FA), located in the most prominent part of the vestibular coronal center in premolars and in the center of the mesiovestibular sulcus in first molars; the WALA point, located perpendicular to the occlusal plane at the mucogingival junction. The data of the measurements obtained were saved in the Microsoft office Excel 2019 program. The average of the measurements obtained was analyzed using SPSS software for Meshmixer values as well as in 3D Slicer. The results are presented in tables.Statistically significant discrepancies were found for the values obtained from the STL files compared to the CBCT DICOM files especially because the latter only evaluate hard tissues for WALA edge measurements.The values obtained largely resemble the values described by Will Andrews, however, these differ significantly in relation to the unit of analysis of DICOM files the same that lack scientific support to be taken into account as a diagnostic measurement of the WALA edge. Some of the differences in values obtained for WALA edge measurements between different study populations may be due to the fact that several studies use the manual or conventional method and others the digital method and even the same scanner or software used in the digital measurement of models may cause discrepancies in the measurements.

Key Words:STL,DICOM,facialaxis(FA),WALApoint.

DOI Number: 10.14704/nq.2022.20.6.NQ22159 **NeuroQuantology2022; 20(6):1636-1642**

Introduction

Dentistry in the 21st century is supported by constant technological advancement;digital models have eliminated the need for storage space and have facilitated theretrieval and transfer of models.These three-dimensional models can be easilymanipulated to collect measurements to facilitate diagnosis and treatment planning.With the many advantages of digital models, they will replace traditional plastermodels.Alimitationtocorrectdiagnosisistocontinuetorelyonlastcenturymethodsof analysis, technological advances encompass every area of our lives, dentistryand/ororthodonticsisnoexception,2DmeasurementsandtheuseofphysicalmodelsarebeingreplacedbytheuseofdentalscanningandtheuseofCBCTthusmaintainingatruepicture ofthepatient'sanatomicalandfunctionalconditions. TheWALArimisanacronymofWillAndrewsandLarry Andrewswhocollaboratedinits discovery. (1)(2)(3)

The WALA ridge is defined as the junction between the basalbone and the alveolar bone. It corresponds clinically to the mucogingival line, (Figure1). This analysis compares the distances between the center of the clinical crown oftheteethwiththedistancebetweentheprojectionsof thesepointsonthemucogingivalline. (4)(5) However, the thickness of the soft tissue, which varies between teeth, canaffect the positions of the WALA points.Wala analysis helps us to evaluate changesin the lower arch and determine the amount of transverse development that will beobtainedwithorthodontictreatment(5).Thisanatomicalreferenceisalsoidentifiedonplastermodels,asthemostprominentpartofthevestibularfacewhereitcorrespondsto the bone.(6)

Address: [1,2,3]FacultyofDentistry,UniversityofCuenca.
E-mail: [1]estuardo.bravo@ucuenca.edu.ec , [2]marco.bernal@ucuenca.edu.ec, [3]ruben.zhingre@ucuenca.edu.ec

Figure1.TheWALArimisthejunctionbetweenthe basalbone andthe alveolarbone.
Source:Authors

Fromtheirearliestyearsofusecephalogramswerewidelyappliedasatoolforclinical,developmental and treatment effects and outcomes research. Beyond its use as adiagnostic tool, the errors inherent in 2D cephalometry and subsequent analysis arewell documented. Significant errors are associated with ambiguity in the localizationofanatomicalstructures,duetothelackof well-definedanatomicalfeatures,contours,shadows and variation in patient position. The use of 3D diagnostic methods greatlyimproves the definition of the anatomical structures to be studied, providing greaterefficiency in studies based on the same. (7)(8) Cone beam computed tomography(CBCT) is widely used in the oral and maxillofacial region, due to its lower effectiveradiationdose and lower costin relationto CT.(9)

TheobjectiveofthisstudywastodescribetheWALAedgeinstudentsoftheseventhcycle of the Faculty of Dentistry of the University of Cuenca using digital models andCBCT,aswellastodeterminewhichdiagnostictoolisthe closesttoreality,contrastingwith thevaluesgiven by theauthorsWilliamand Andrews.

Materials and methods:

Descriptive observational study. The sample consisted of 49 men and women fromthe dental school of the University of Cuenca, in the age range between 23 and 33years.Ofthe49participants,36 werechosenbecausetheymettheinclusioncriteria:
1. patients with intact first premolars, second premolars and lower permanent firstmolars;2.whopresentedDICOMmodelswithoutimagedefectsintheCBCTacquisition;3.whosignedinformedconsent.3whohavesignedtheinformedconsent form.

ThedigitalmodelswereacquiredinOctober2021byoneoperatorwithaSironaCADCAM scanner (Cerec OMNICAM, Sirona Dental GmBH, Wals Bei Salzburg, Austria)and exported in STL format for WALA edge analysis. CBCT CT scans were taken byanother operator in November 2021 with 3D J Morita Accuitomo 170 equipment withthe following technical parameters: field of view (FOV) 170 mm x 120 mm, slicethickness0.33mmandsliceinterval0.66mmexportedinDICOMformat.TheDICOMfiles were imported into the 3D Slicer radiological software (US National Institutes ofHealth,Version4.11.20) forWALAedgeanalysis.(Figure2)

To describe the WALA edge, the Facial Axis (FA) point was determined (Figure 4)located at the most prominent point of the vestibular coronal center in premolars andatthecenterofthemesiovestibularsulcusinfirstmolars;theWALApointwaslocatedperpendiculartothe occlusalplaneatthemucogingivaljunction.Theunitof measurement was in mm using two decimal places. The measurement data obtainedwere saved in Microsoft office Excel 2019 (Microsoft, Redmond, WA, USA). Themeasurements were performed by one operator for the STL files and another for theDICOMfiles. 1637

TheaverageofthemeasurementsobtainedinMeshmixeraswellasin3DSlicerwereprocessedusingSPSSStat isticalPackagesfortheSocialSciencesversion20software(IBMCorp.;Armonk,NY,USA).Figure3.Theresults werereflectedintables.The statistical analysis of the data was processed through the SPSS program bymeans of Student's t-test calculations for related samples, where 95% confidenceintervalswereapplied. (Table 3).

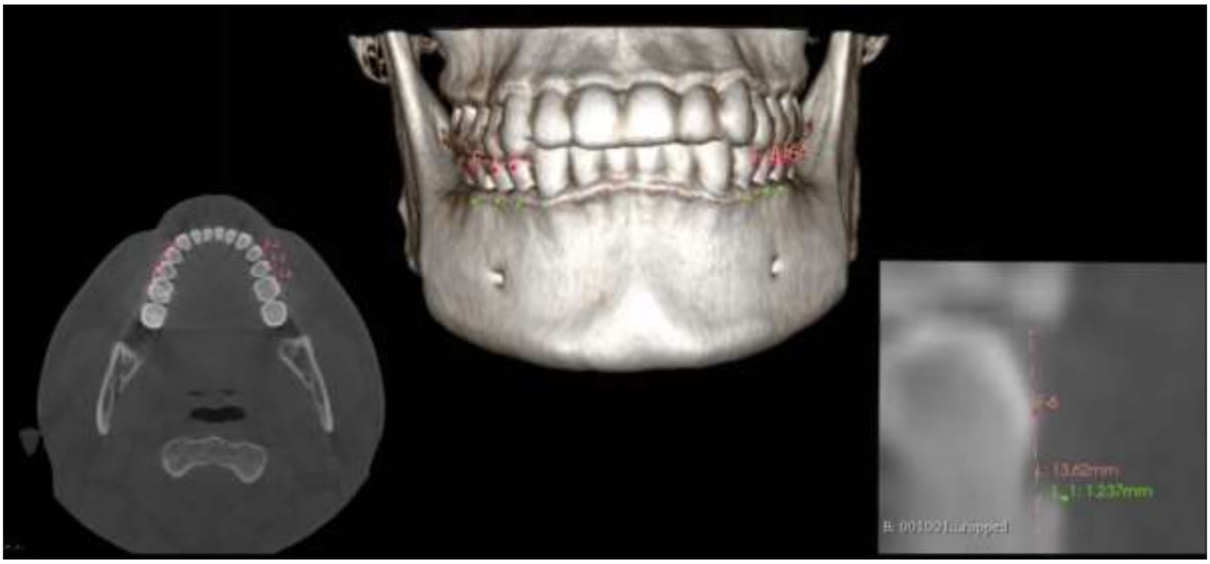

Figure2:WALAborderonCBCT, FApointpink;WALApoint green.
Source:Authors

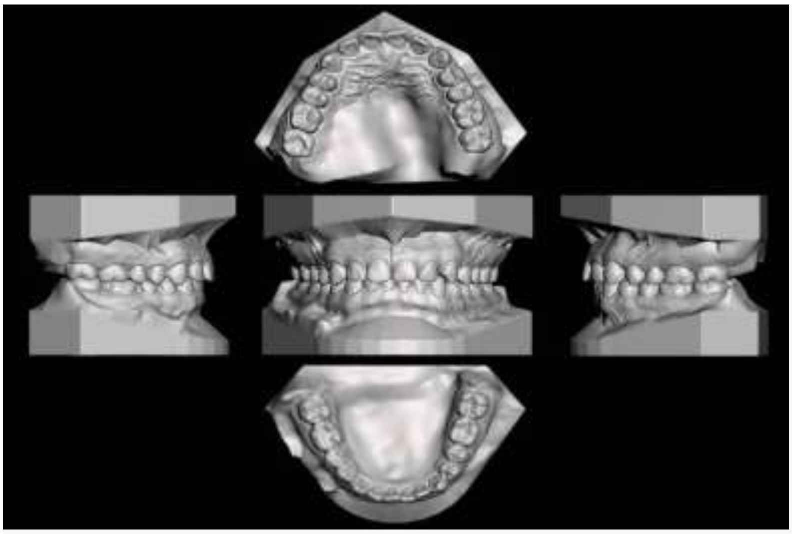

Figure3: Viewof theMeshmixerdigitalmodelofoneofthepatients.
Source:Authors

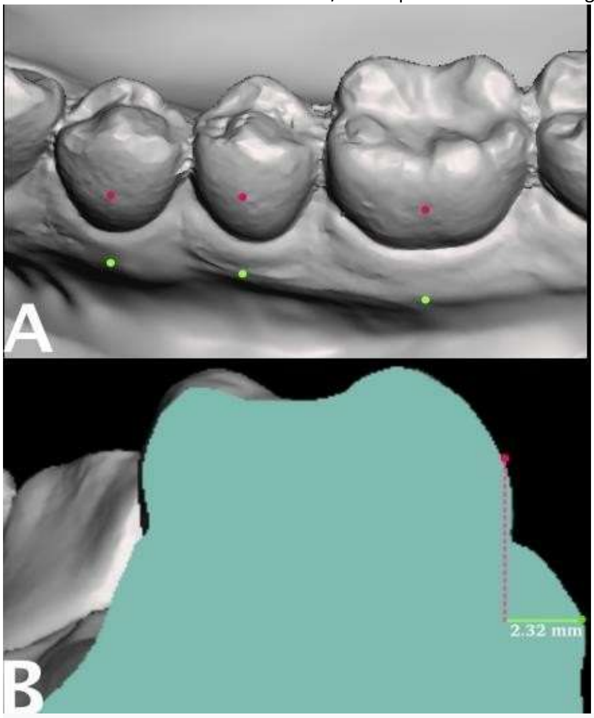

Figure4:WALAanglemeasurement inSTL.(A)FApointinpink andWALApointingreen;(B)TransversedistancebetweenFAandWALApoints.
Source:Authors

Results

Oncethedatawereanalyzed,itwasobservedthatthestudypopulationconsistedof72.2%(N=26) of femalesand 27.8%(N=10)ofmales (Table 1).

Table1.Characterizationofthestudypopulationaccordingtosex.

		Frequency	Percentage
Valid	**FEMALE**	**26**	**72,2**
	MALE	**10**	**27,8**
	Total	**36**	**100,0**

Source:Authors

Theageoftheparticipantsrangedfrom23to33years;theiraverageagewas25.8years(SD=2.2years)(Table 2).

Table2.

Statistics		
Ageofpatients		
N	**Valid**	**36**
	Lost	**0**

Media	**25,83**
DeviationDeviation	**2,236**
Minimum	**23**
Maximum	**33**

Source:Authors

Asforthestatisticaldataontheageofthepatients,themeanagewas25.8years,theminimumwas23yearsandthemaximum was33years,therewasadeviationof2.2.

Table3. Comparisonofmeans.

		PAIRED SAMPLES TESTMATCHEDDIFFERENCES		
		95%confidenceintervalofthedifference		**Sig (Bilateral)**
		Inferior	**Superior**	
Par1	**FIRST MOLAR #46 - FIRSTMOLAR 46**	**-1,09513**	**-0,87876**	**,000**

Par2	**SECOND PREMOLAR #45 - SECOND PREMOLAR #45 - SECONDPREMOLAR 45**	**-0,88791**	**-0,63543**	**,000**
Par3	**FIRST PREMOLAR #44 - FIRSTPREMOLAR44**	**-0,84326**	**-0,69397**	**,000**
Par4	**FIRST PREMOLAR #34 - FIRSTPREMOLAR34**	**-0,85887**	**-0,64613**	**,000**
Par5	**SECOND PREMOLAR #35 - SECOND PREMOLAR #35 - SECONDPREMOLAR 35**	**-0,93754**	**-0,76857**	**,000**
Par6	**FIRST MOLAR #36 - FIRSTMOLAR 36**	**-1,05842**	**-0,87103**	**,000**

Source:Authors

Thepaireddifferencevalueswerewithinthepairwisecalculation:1pair,firstmolar4.6(-1.05,-0.8);2pair,secondpremolar4.5(-0.8,-0.6);3pair,firstpremolar4.4(-0.8,-0.6);4pair,firstpremolar3.4(-0.8,-0.6);5 pair,second premolar3.5(-0.9,-0.7)and 6pair,firstmolar3.6(-1.05, -0.8).Valuesobtainedwith95% reliability.
Statistically significant discrepancies were found for values obtained from STL filescompared to CBCT DICOM files especially because the latter only evaluate hardtissuesfor WALAedge measurements.

Table4:FAdistanceandWALAedgeaverages.
Studysamplereport inSTL

1stPremolar		2ndPremolar	1stMolar
Media	0,7532	1,1692	2,0135
DeviationDeviation	0,40261	0,48600	0,48908
Minimum	-0,63	-0,33	0,73
Maximum	1,65	2,16	3,13

ThepresentstudyreflectedvaluesoftheWALAridgemeasuredintheSTLmodelsof 0.75mmforfirstpremolars,1.16mmforsecondpremolarsand2.01mmforlowerfirstmolars.ThevaluesobtainedbetweentheFApointandtheWALAcrestwereprogressive in the anteroposterior direction, being lower for the premolars and higherin the first molar. The table was obtained by adding the right and left values of eachtoothcorresponding tothedental arch.

Discussion

In the present study the WALA-FA values of 36 patients were obtained in digitalmodels in STL format and contrasted with CBCT of the same patients to determinetheir differences and whether one method is more reliable than the other; the WALAedge is of great importance in orthodontics since this analysis has been taken as adiagnosticreferencetodeterminetheamountofexpansionthatwillbeachievedattheend of orthodontic treatment. (10) This method indicates the ideal dental positionwithoutexceedingtheexpansionlimitsduringorthodontictreatmenttoavoidperiodontalproblemsandunstableorthodontictreatment.(11)(4)(12)
Formerly WALA edge measurements were performed on plaster models, but amongthe disadvantages of this method, only linear measurements could be performed onthesemodels,otherdisadvantagesarethatthesemodelspresenteddeteriorationwiththe passage of time, the reliability of the material used was not the best and theyrequirephysicalstoragespace.(6)(12)Currentlythishasbeenevolvingandtheyhavebeenreplacedbythree-dimensionaldigitalmodelsthatareobtainedbyintraoralscansand are managed by software that allows their manipulation and also allows greateraccuracy.(5)(13)3Dmanagementsoftwareisconstantlychanging,onestudyshowedthatascanfromtwoyearsagomayyielddifferentresultsifrepeatedtoday.(14)
According to Sibert et al. in their study they mention that the ideal Andrews distancesattheleveloffirstpremolarsis0.8mm/side,1.3mm/sideinsecondpremolarsand2 mm/side in lower first molars. (15) Our study applied to a group of Ecuadoriannationals obtained values very close to those mentioned above, being 0.75 mm

forfirst premolars, 1.16 mm for second premolars and 2.01 mm for lower first molars.However,otherstudiessuchasthatofBhandari etal.inanIndianpopulationshowedresultsof1.17mmf orfirstpremolars,1.53mmforsecondpremolarsand2. 04mmforlowerfirstmolars.(16)AlsoKongetal.inthei rstudyofaPeruvianpopulationobtainedvalues of 0.96 mm for first premolars; 1.45 mm in second premolars and 2.12 mm inlower first molars (17). On the other hand, Tribiño et al. in their study of a Brazilianpopulation showed values of 0.88 for first premolars; 1.55 mm in second premolarsand 2.21 mm in lower first molars. (3) The values higher than those established byAndrews show a clear lingualization of the posterior teeth in the populations studied.An important fact that should be taken into account is that the thickness of the softtissues varies between teeth, therefore, this may affect the positions of the WALApoints.(18)

Cone beam computed tomography (CBCT) has become a rapidly evolving imagingtechnique in orthodontics, since due to its more advanced diagnostic capabilities, ithas allowed us to obtain treatment planning in a three-dimensional (3D) format. (19)Although this method is very effective, it has caused controversy, since the patientmust be exposed to radiation to obtain the results. (20) In this study we sought tocomparetheDICOMandSTLfiles,butastatisticallysi gnificantdifferencewasfound,which lies in the way of tracing the WALA points, since in the STL file software dentaltissue, bone tissue and soft tissue can be measured, whereas in the DICOM formatthesofttissuepointswerenotconsideredinthei mages,thereforethismakesitdifficulttoproperlyiden tifytheabovementionedpointsusingCBCTandhencet hemeasurement results differ greatly between the two diagnostic methods. However,somestudieshaveusedCBCTtotracethetraj ectorythatdescribesthearcgeneratedby the points of the root center (RC) that corresponds to the WALA point, but locatedinthebasal bone. (5)(21)

Conclusions

Thefollowingconclusionsweredrawnfromthisstudy: From the measurements obtained from the analysis sample it was concluded that thevalues in the STL models largely resemble the values described by Will Andrews,however,theydiffersignificantlyinrelationt otheunitofanalysisofDICOMfileswhichlackscientific supporttobetakenintoaccountas ameasurementoftheWALAedge.

Some of the differences in values obtained for WALA edge measurements betweendifferentstudypopulationsmaybeduetothef actthatseveralstudiesusethemanualor conventional method and others the digital method and even the same scanner orsoftware used in the digital measurement of models may cause slight discrepanciesinthemeasurements.

It would be useful to carry out future studies taking into account larger populations toconfirm the results we have obtained, in addition to following up the present study interms of the results obtained and taking into account interobserver reliability in aprudenttimeframe,since thisstudy couldnotbecarriedoutin thisstudy.

References

Andrews LF. The 6-elements orthodontic philosophy: Treatment goals, classification,and rules for treating. Am J Orthod Dentofacial Orthop [Internet]. 2015 Dec [cited 2021 Dec 16];148(6). Available from: https://pubmed.ncbi.nlm.nih.gov/26672688/

Ball RL, Miner RM, Will LA, Arai K. Comparison of dental and apical base arch formsin Class II Division 1 and Class I malocclusions. Am J Orthod Dentofacial Orthop [Internet]. 2010 Jul [cited 2021 Dec 17];138(1). Available from: https://pubmed.ncbi.nlm.nih.gov/20620832/

Triviño T, Siqueira DF, Andrews WA. Evaluation of distances between the mandibular teeth and the alveolar process in Brazilians with normal occlusion. Am J Orthod Dentofacial Orthop [Internet]. 2010 Mar [cited 2021 Dec 17];137(3). Available from: https://pubmed.ncbi.nlm.nih.gov/20197165/

Gonzalez AG, Lopez AF, Fernandez ST, Ocampo AM, Valencia JE. Sensibilidad y especificidad de un análisis radiográfico, tomográfico y de modelos digitales en la determinación de discrepancias transversales. Rev Mex Ortodon. 2018 Apr 6;6(1):28–34.

Suk KE, Park JH, Bayome M, Nam Y-O, Sameshima GT, Kook Y-A. Comparison between dental and basal arch forms in normal occlusion and Class III malocclusions utilizing cone-beam computed tomography. Korean J Orthod. 2013 Feb;43(1):15.

Bravo G, Gonzáles G. Análisis de la distancia entre los dientes mandibulares posteriores y el borde wala en modelos digitales 3d. [Pregrado]. [Internet]. [cited 2021 Dec 17]. Available from: https://1library.co/document/q05o3d3y-analisis-distancia-dientes-mandibulares-posteriores-borde-modelos-digitales.html

Roque-Torres GD, Meneses-López A, Norberto Bóscolo F, De Almeida SM, Haiter Neto F. La tomografía computarizada conebeam en la ortodoncia, ortopedia facial y funcional. RevistaEstomatológicaHerediana. 2015;25(1):61–78.

Slaj M, Spalj S, Pavlin D, Illes D, Slaj M. Dental archforms in dentoalveolar Class I, II and III. Angle Orthod [Internet]. 2010 Sep [cited 2021 Dec 17];80(5). Available from: https://pubmed.ncbi.nlm.nih.gov/20578864/

Gerke BA, Yamashita AL, Sigua-Rodriguez EA, Olate S, Iwaki LCV, Iwaki-Filho L. Análisis Descriptivo y Cualitativo de Tres Software Gratuitos Usados para la Conversión de Formato DICOM para STL. Int J Odontostomat. 2019;13(1):103–11.

Fonseca MTA, Moreno MI, Lanata A. Análisis de Wala Ridge para evaluar cambios transversales del arco inferior en pacientes tratados con sistemas de autoligado. Univ Odontol [Internet]. 2014 Jun 30 [cited 2022 Jan 22];33(70). Available from: https://revistas.javeriana.edu.co/index.php/revUnivOdontologica/article/view/5236

Ronay V, Miner RM, Will LA, Arai K. Mandibular arch form: the relationship between dental and basal anatomy. Am J Orthod Dentofacial Orthop [Internet]. 2008 Sep [cited 2021 Dec 16];134(3). Available from: https://pubmed.ncbi.nlm.nih.gov/18774089/

Lalangui J, Juca C, Molina A, Lasso G, Yunga Y. Métodos diagnósticos para estudio de anomalías dentomaxilares en sentido transversal. Revisión bibliográfica [Internet]. [cited 2022 Jan 23]. Available from: https://www.ortodoncia.ws/publicaciones/2020/art-68/

Dindaroğlu F, Duran GS, Tekeli A, Görgülü S, Doğan S. Evaluation of the Relationship between Curve of Spee, WALA-FA Distance and Curve of Wilson in Normal Occlusion. Turk OrtodontiDerg. 2016 Dec;29(4):91.

Mennito AS, Evans ZP, Lauer AW, Patel RB, Ludlow ME, Renne WG. Evaluation of the effect scan pattern has on the trueness and precision of six intraoral digital impression systems. J Esthet Restor Dent [Internet]. 2018 Mar [cited 2022 Jan 22];30(2). Available from: https://pubmed.ncbi.nlm.nih.gov/29476599/

Silbert M, Benedetti M, Zanier B, Jiménez L. WALA Ridge y las distancias ideales de Andrews [Internet]. Postgrado en Odontología. Clínica Universitaria. 2021 [cited 2022 Jan 22]. Available from: https://odontologiaucam.com/articulos/articulo-cientifico-wala-ridge-y-las-distancias-ideales-de-andrews/

Bhandari V, Singla A, Mahajan V, Jaj HS, Seth V. Evaluation of Distances between the Mandibular Teeth and the Alveolar Process in Himachali Population with Normal Occlusion. 2012 [cited 2022 Jan 22]; Available from: https://doi.org/10.5005/jp-journals-10021-1110

Kong-Zárate CY, Carruitero MJ, Andrews WA. Distances between mandibular posterior teeth and the WALA ridge in Peruvians with normal occlusion. Dental Press J Orthod [Internet]. 2017 [cited 2022 Jan 22];22(6). Available from: https://pubmed.ncbi.nlm.nih.gov/29364380/

Cha BK, Lee YH, Lee NK, Choi DS, Baek SH. Soft tissue thickness for placement of an orthodontic miniscrew using an ultrasonic device. Angle Orthod [Internet]. 2008 May [cited 2022 Jan 22];78(3). Available from: https://pubmed.ncbi.nlm.nih.gov/18416626/

Kau CH, Li JL, Li Q, Abou KN. Update on cone beam technology and orthodontic analysis. Dent Clin North Am [Internet]. 2014 Jul [cited 2022 Jan 22];58(3). Available from: https://pubmed.ncbi.nlm.nih.gov/24993927/

Palomo JM, Kau CH, Palomo LB, Hans MG. Three-dimensional cone beam computerized tomography in dentistry. Dent Today [Internet]. 2006 Nov [cited 2022 Jan 22];25(11). Available from: https://pubmed.ncbi.nlm.nih.gov/17128717/

O'Neil R, Kau CH. Comparison of dental arch forms created from assessment of teeth, alveolar bone, and the overlying soft tissue. J Orofac Orthop [Internet]. 2021 Nov [cited 2022 Jan 23];82(6). Available from: https://pubmed.ncbi.nlm.nih.gov/33740063/