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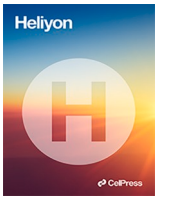

Two-dimensional facial measurements for anterior tooth selection in complete denture treatment

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A B S T R A C T

Purpose: Anterior tooth selection is one of the most challenging parts in determining tooth dimensions and critical to the aesthetic aspect of the complete denture treatment. However, the methods for anterior tooth size selection using facial measurements are still controversial. This study aimed to investigate the relationship between dental measurements and facial measurements, and to establish the anterior tooth size prediction equation using facial dimensions in the Thai population for the complete denture treatment.

Materials & methods: One hundred and twenty-five Thai participants (53 men and 72 women) aged 18–35 years old with Angle class I occlusion, did not currently undergo orthodontic treatment, had normal alignment on the maxillary anterior teeth, no attrition, abrasion, proximal restoration or prosthesis were investigated. One frontal facial photograph and one dental photograph of each participant were made using an image analyzing program (ImageJ version 1.53b) to measure the six horizontal facial distances, five vertical facial distances and three dental distances as 2D facial and dental measurements. Pearson correlation and multiple linear regression analysis were performed.

Results: The difference of facial and dental measurements between men and women were statistically significant ($P < .001$). Interpupillary width, interlateral canthal width, intercommissural width and bizygomatic width were correlated to dental measurements in both sexes. Intermedial canthal width and lip thickness were correlated to dental measurements in women. Face length and lateral canthus to lower border of face were correlated to dental measurements in men. Prediction equations of each dental measurement were established using only horizontal facial dimension and using both horizontal and vertical facial dimensions.

Conclusions: Facial and dental dimensions are sex-dependent. Facial measurements can be applied in a regression equation to predict dental measurements. Adding vertical dimensions of facial measurements to the prediction equations of anterior tooth size selection results in a higher R squared to 0.444. This finding can be used as a tool for anterior tooth size selection in the complete denture treatment.

1. Introduction

Complete dentures serve the purpose of replacing lost dentition, both functionally and aesthetically. The aesthetic aspect of complete dentures is one of the major concerns and should meet the satisfaction of the patient, which relies greatly on the anterior teeth due to their prominent position and configuration. Anterior tooth selection is one of the most challenging parts of determining tooth dimension and critical to the aesthetic aspect of a complete denture [1].

In maxillary anterior tooth selection, artificial intelligence (AI) has been widely applied [2,3]. Moreover, pre-extraction records,

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such as diagnostic casts or photographs of the patient, are frequently used. When those data are unavailable, the dimensions of the face have been widely accepted for the estimation of tooth size [4]. Several studies assessed the relationship between anterior tooth width and single facial measurement such as bizygomatic width (BZW) [5,6], interpupillary width (IPW) [6–8], intermedial or interlateral canthal width (MCW, LCW) [9–11], interalar width (IAW) [1,5,8,12], and intercommissural width (ICW) [13–15] and found varied degrees of correlation related to sex [1,6,7,12] and ethnicity [15,16].

Some studies had shown an unreliable association between these facial measurements and tooth width, indicating that single facial measurement was not accurately enough for dental width estimation [5] thus leading to poor clinical accuracy. In order to refine such issues, the complex statistical models for multiple measurements analysis were applied to combine many facial measurements together to increase the reliability rather than using a single facial landmark. Using the combination of facial measurements for estimating the tooth width were found in many studies [17–19]. The IPW,ICW LCW, MCW and IAW were taken into account for investigated their relationship to the central incisors width (IW) in Malaysian, Chinese, Kurdish and Turkish population. However, these studies demonstrated that the acquired prediction equation of multiple analysis also varied among different ethnicities and there is a greater reliability when the larger the number of measurements is incorporated into an equation.

Moreover, Sinavarat et al. found that not only ICW but also the distance from inner canthus of the eye to the ala of the nose were strongly correlated to dental measurement in Thais [14]; this supported that the non-horizontal facial measurements can be used to predict the horizontal dental width. In addition, it indicated the role of vertical facial measurement in the dental measurement equation as it helps increase the accuracy and reliability of the prediction equation in clinical use. The measurements in previous studies were limited to horizontal facial distance thus there was a lack of information of vertical facial distance.

Therefore, this study aimed to determine the relationship between dental measurements and facial dimensions, both horizontal and vertical distances integrating into multiple variables analysis to strengthen the prediction equation for anterior tooth selection for complete denture treatment in the Thai population. The research hypothesis of the study was that the facial measurements can be used to estimate the anterior tooth size for both sexes.

2. Materials and methods

This study was approved by Mahidol University, Institutional Review Board COE.No.MU-DT/PY-IRB 2022/017.1003. One hundred and twenty-five participants, 53 men and 72 women with age between 18 and 35 years old, were enrolled. Participants acquired Angle class I occlusion, did not currently undergo orthodontic treatment, and had normal alignment on the maxillary anterior teeth. Their maxillary anterior teeth had no attrition, abrasion, proximal restoration or prosthesis. Participants who had abnormally shaped tooth, facial deformity, cosmetic treatment or plastic surgery of the face were excluded.

The participant's face was allocated at a standardized position which was at a resting state in maximal intercuspal position of dentition before all images are made. The parallelism of the participant's Frankfort horizontal plane and interlateral canthal distance to the floor was verified. All photographs were made by one investigator (PP) with the use of the camera Fujifilm X-A2 with a 16–50 mm f/3.5–5.6 OIS II lens. The center of every participant's face was marked at the same reference point in the center of the image. The standardized ruler was placed next to the participant's face. Photographs in resting states were made. The participant was allocated at the same position as the resting state. Then they were asked to smile until all upper anterior teeth were clearly seen. Dentition photographs in smiling states were made.

All photographs were imported into an image analyzing program (ImageJ Version 1.53b). The scale of the measurement on the photographs were defined according to the two marked reference points. Measurements of all photographs were averaged between two researchers (PP and TA). The intraclass correlation coefficient was analyzed for inter-examiner reliability. The parameter of soft tissue points, facial landmarks and dental landmarks are shown in Tables 1–3, respectively. Horizontal and vertical lines were drawn on the facial photographs to determine measurement of facial landmarks shown in Fig. 1 and dental landmarks in Fig. 2. Participant consented to have these images published.

The statistical analysis was carried out by IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY). The level of significance for all statistical tests was at 0.05. Intraclass correlation coefficient was used for interobserver reliability. The differences of measurements between sex were determined by independent samples *t*-test and the difference between right and left incisor width and height were determined by paired *t*-test. The relationship between each dental and facial measurement was analyzed by Pearson's correlation analysis. The multiple linear regression analysis was used to determine the prediction of each dental measurement using facial measurements. Regression equations were developed from two separate calculations; 1) equation for dental measurements using

Table 1
Description of soft tissue points.

Soft tissue points	Description
Alar (A)	The most lateral point of alar
Lip Commissure (CO)	The most lateral point where upper lip joins lower lip
Medial canthus (MC)	The medial junction between upper eyelid and lower eyelid
Lateral canthus (LC)	The lateral junction between upper eyelid and lower eyelid
Pupil (P)	The center of pupil
Zygion (Zy)	Most lateral point of the soft tissue overlying zygomatic bone
Trichion (Tr)	Point in midline at the junction of hairline and forehead
Gonion (Go)	Point in midline at the most inferior point of the soft tissue overlying mandible

Table 2
Description of horizontal and vertical facial landmarks.

Facial landmarks	Description
Horizontal dimension	
Interpupillary width (IPW)	Right P - Left P
Interlateral canthal width (LCW)	Right LC - Left LC
Intermedial canthal width (MCW)	Right MC - Left MC
Interalar width (IAW)	Right A - Left A
Intercommissural width (ICW)	Right CO - Left CO
Bizygomatic width (BZW)	Right Zy - Left Zy
Vertical dimension	
Face length (FL)	Tr - Go
Lateral canthus to hairline (LCH)	Average distance of vertical lines from right and left LC - hairline
Medial canthus to hairline (MCH)	Average distance of vertical lines from right and left MC - hairline
Lateral canthus to lower border of face (LCF)	Average distance of vertical lines from right and left LC - lower border of face
Lip thickness (LT)	Point in midline at the most superior point of upper lip - Point in midline at the most inferior point of lower lip

Table 3
Description of horizontal and vertical dental landmarks.

Dental landmarks	Description
Horizontal dimension	
Intercanine distance (ICD)	Distance between most inferior point of left and right maxillary canine
Right central incisor width (IWr)	Distance perpendicular to the long axis between mesial and distal contact point of right maxillary central incisor
Left central incisor width (IWl)	Distance perpendicular to the long axis between mesial and distal contact point of left maxillary central incisor
Central incisor width (IW)	Average distance of IWr and IWl
Vertical dimension	
Right central incisor height (IHr)	Distance parallel to the long axis between most superior point of gingival margin and incisal edge of right maxillary central incisor
Left central incisor height (IHl)	Distance parallel to the long axis between most superior point of gingival margin and incisal edge of left maxillary central incisor
Central incisor height (IH)	Average distance of IHr and IHl

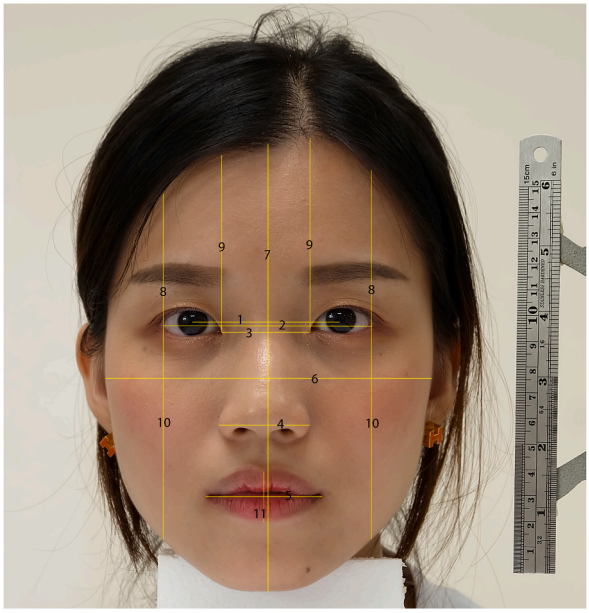

Fig. 1. Interpupillary width; IPW(1), Interlateral canthal width; LCW(2), Intermedial canthal width; MCW(3), Interalar width; IAW (4), Intercommissural width; ICW(5), Bizygomatic width; BZW (6), Face length; FL (7), Lateral canthus to hairline; LCH(8), Medial canthus to hairline; MCH (9), Lateral canthus to lower border of face; LCF(10), Lip thickness; LT (11).

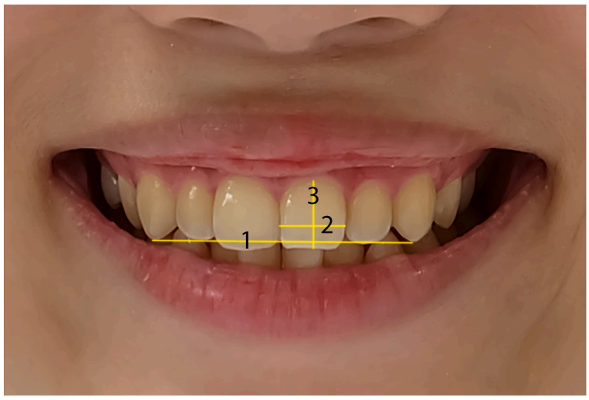

Fig. 2. Intercanine distance; ICD(1), Central incisor width; IW(2), Central incisor height; IH(3).

horizontal facial measurements, and 2) equation for dental measurements using all facial measurements. The face ratio, face length (FL) and BZW, and the central incisor ratio, central incisor height (IH) and central incisor width (IW), were calculated. The relationship between these ratios were analyzed by Pearson's correlation analysis. The methodology flowchart was presented in Fig. 3.

3. Results

The intraclass correlation coefficients were .922–.974, showing high agreement between observers. It was found that there was a statistically significant difference in the dental and facial landmarks measurements between men and women. Then, all analysis was investigated separately between sexes. There was no statistically significant difference between right and left incisor width and height. In men, intercanine distance (ICD) correlated with IPW, LCW, ICW, FL, lateral canthus to lower border of face (LCF) ($P < .05$). IW correlated with IPW, ICW, BZW, FL, LCF ($P < .05$). IH correlated with IPW, LCW, FL, LCF ($P < .05$) In women, ICD correlated with IPW, LCW, MCW, ICW, BZW, lip thickness (LT) ($P < .05$). IW correlated with IPW, LCW, LT ($P < .05$). IH shows correlation with IPW ($P = .034$). However, none of the dental measurements in both sexes correlated with IAW, lateral canthus to hairline (LCH), medial canthus to hairline (MCH) ($P > .05$) as shown in Table 4. Prediction equations were developed using multiple regression analysis. In men, ICD can be predicted by IPW and ICW from horizontal measurements and by IPW, ICW and LCH from all measurements. In women, ICD can be predicted by LCW from horizontal measurements and by LCW and MCH from all measurements. In men, IW can be predicted by BZW from horizontal measurements and by LCF from all measurements. In women, IW can be predicted by LCW from horizontal measurements and by LCW and LT from all measurements. In addition, IH in both sexes can be predicted by IPW from both horizontal measurements and all measurements as shown in Table 5. The relationship between face ratio (FL/BZW) and incisor tooth ratio (IH/IW) was not found ($P > .05$).

4. Discussion

Since universal agreement on the method of anterior tooth selection is not established, this issue remains confusing and challenging for clinicians to gain the appropriate tooth size for edentulous patients, especially for aesthetic appraisal. Generally, the anterior tooth was suggested to be selected to harmonize with face proportion. This method, however, required considerable experience, which would be a burden for an inexperienced dentist. Therefore, the refinement of using facial distance, including both horizontal and vertical measurements, as a guide for tooth selection should be interesting as these would lessen the need for the experience-based judgement.

The present study, in agreement with previous ones [1,6,7,12], found a statistically significant difference in males measurements from that in females. Moreover, the relationship between dental distance and facial distance showed different results in males and females in both single and multiple correlation aspects. Therefore, the prediction equation for artificial teeth size of the two sexes should be considered separately. Comparing these relationships in different nationalities, the study done in Malaysian and Chinese populations [17] found that IW is associated with only IPW, which is in agreement with the study in the Kurdish population [18]. On the other hand, the study performed in the Turkish population [19] reported the association of IW to the combination of LCW, MCW and IAW in women, but to the combination of IPW, ICW, LCW and IAW in men, thus further supports the belief of the racial difference of dental-facial proportion. Conducting the prediction equation from the measurements collected from one population would, therefore, be more accurate and beneficial to apply for use in that population.

This study did not only support that horizontal facial measurements could be applied in choosing anterior teeth, but also illustrate how vertical facial measurements are correlated with teeth size. When including the vertical facial measurements with the horizontal into the analysis, the coefficient of determination was higher in both ICD and IW prediction equations, reflecting an increase in the accuracy in estimating the anterior teeth dimensions by adding the vertical measurements into consideration. The reason behind this phenomenon might be that both horizontal and vertical dimensions of the face and teeth share the same embryonic origin [20].

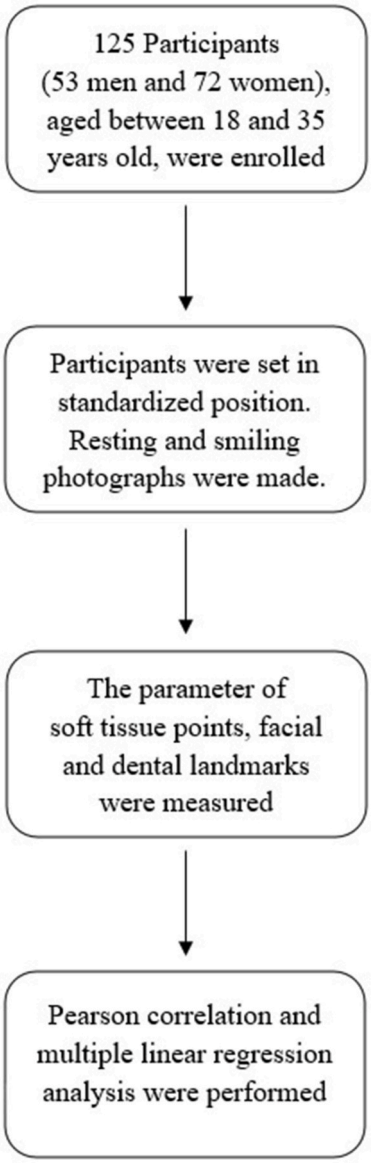

Fig. 3. Methodology flowchart.

Consequently, it is possible that not only horizontal but also vertical dimensions are associated with the width of anterior teeth. Both the horizontal and vertical facial measurements should, therefore, be taken into consideration regarding the calculation of dental measurement. However, the face ratio and the incisor tooth ratio were not correlated. This result revealed that some facial measurements were related to dental measurements, but some were not related. Adding more variables only means increasing its coefficient of determination, thus the prediction equation could be further improved by including more horizontal, vertical, or even oblique facial measurements, such as the distance from inner canthus of the eye to the ala of the nose as reported by Sinavarat et al. [14].

To estimate the anterior tooth size using the prediction equation, the dentist needs to measure all facial measurements in the equation, then put these measurements into the equation to calculate the anterior tooth size. However, by requiring more variables, measuring multiple facial measurements in clinical practice can be challenging since it is difficult and time-consuming. This is because the procedure is prone to errors when it comes to measuring soft tissue dimensions due to the movable nature of soft tissues. Therefore, the prediction equations integrating maximum measurements that should result in excellent accuracy might not be as practical to be performed in clinical practices.

Due to these problems, measurements from photographs are more effective in terms of landmark locating, distance measuring, and chair time saving. A development in daily-life technology, such as smartphone application with augmented reality and depth perception, can be made to further help dentists in effectively taking a photograph of a patient, as well as measuring and calculating an

Table 4
Correlation analysis of dental and facial measurements: correlation coefficient (p-value).

Facial measurements	Anterior tooth measurements					
	Men			Women		
	ICD	IW	IH	ICD	IW	IH
Horizontal dimension						
IPW	0.511 (<.001)	0.272 (.049)	0.447 (.001)	0.357 (.002)	0.352 (.002)	0.250 (.034)
LCW	0.430 (.001)	0.132 (.347)	0.298 (.030)	0.431 (<.001)	0.368 (.001)	0.227 (.055)
MCW	0.172 (.218)	−0.126 (.368)	0.179 (.368)	0.391 (.001)	0.112 (.349)	0.215 (.070)
IAW	0.185 (.186)	0.168 (.230)	0.154 (.271)	0.194 (.102)	0.119 (.321)	0.010 (.935)
ICW	0.449 (.001)	0.332 (.015)	0.270 (.050)	0.300 (.011)	0.196 (.099)	0.040 (.738)
BZW	0.215 (.122)	0.332 (.015)	0.108 (.443)	0.326 (.005)	0.231 (.051)	0.106 (.377)
Vertical dimension						
FL	0.334 (.015)	0.367 (.007)	0.288 (.036)	0.047 (.693)	0.060 (.617)	0.209 (.078)
LCH	−0.054 (.699)	0.107 (.448)	0.112 (.424)	−0.070 (.561)	−0.053 (.660)	0.103 (.391)
MCH	0.071 (.612)	0.218 (.116)	−0.054 (.701)	−0.188 (.114)	−0.081 (.499)	−0.005 (.969)
LCF	0.294 (.033)	0.430 (.001)	0.315 (.022)	0.216 (.068)	0.223 (.059)	0.211 (.075)
LT	0.137 (.327)	0.103 (.463)	0.109 (.438)	0.262 (.026)	0.299 (.011)	0.155 (.194)

Table 5
Regression equations of dental measurements from horizontal and all facial measurements: prediction equation, R squared, (p-value).

		Horizontal measurements	Horizontal and vertical measurements
ICD	Men	1.410 + 0.232IPW+0.143ICW	1.538 + 0.299IPW+0.175ICW-0.101LCH
		0.336, (.022)	0.444, (.003)
	Women	1.377 + 0.249LCW	1.950 + 0.285LCW-0.113MCH
		0.185, (<.001)	0.267, (.007)
IW	Men	0.596 + 0.018BZW	0.585 + 0.029LCF
		0.110, (.015)	0.185, (.001)
	Women	0.499 + 0.040LCW	0.457 + 0.035LCW+0.048LT
		0.136, (.001)	0.195, (.028)
IH	Men	0.274 + 0.115IPW	0.274 + 0.115IPW
		0.200, (.001)	0.200, (.001)
	Women	0.509 + 0.070IPW	0.509 + 0.070IPW
		0.062, (.034)	0.062, (.034)

appropriate anterior teeth size. Moreover, the AI and deep learning-based dental restoration methods is expected to be an effective technology to solve this problem in the future [21–24]. With the aid of technology, a single photograph will provide sufficient information for anterior tooth selection in complete denture fabrication.

It is noted that the samples of this study were limited only in Thai population. Moreover, the age of the sample was 18–35 years, but the patients who need complete denture treatment were elderly. Therefore, the further study with multiple population groups due to the different facial dimensions, and the study for evaluating the accuracy of these prediction equations with elderly samples would be recommended.

5. Conclusion

The results from this clinical study can be concluded as followings:

1. Facial and dental measurement are sex-dependent.
2. Facial measurement can be applied in a regression equation with R^2 ranges from 0.062 to 0.444 to predict anterior teeth sizes.
3. Vertical facial measurement can increase accuracy of regression equation when combined with horizontal facial measurement.

Author contribution statement

Panjit Chunhabundit: Conceived and designed the experiments; Wrote the paper. Phurinut Prateepamornkul: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Tawepong Arayapisit: Conceived and designed the experiments; Performed the experiments; Wrote the paper. Nuttha Teavirat, Pitchaporn Tanachotevorapong, and Phattarnan Varrathyarom,: Performed the experiments; Wrote the paper. Natchalee Srimaneekarn,: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

References

[1] W. Hoffman Jr., T.J. Bomberg, R.A. Hatch, Interalar width as a guide in denture tooth selection, J. Prosthet. Dent 55 (1986) 219–221.
[2] N. Dai, X. Yu, Q. Fan, F. Yuan, L. Liu, Y. Sun, Complete denture tooth arrangement technology driven by a reconfigurable rule, PLoS One 13 (6) (2018), e0198252.
[3] X. Yu, X. Cheng, N. Dai, H. Chen, C. Yu, Y. Sun, Study on digital teeth selection and virtual teeth arrangement for complete denture, Comput. Methods Progr. Biomed. 155 (2018) 53–60.
[4] P.N. Sellen, B. Phil, D.C. Jagger, A. Harrison, Methods used to select artificial anterior teeth for the edentulous patient: a historical overview, Int. J. Prosthodont. (IJP) 12 (1999) 51–58.
[5] F.R. Scandrett, P.E. Kerber, Z.R. Umrigar, A clinical evaluation of techniques to determine the combined width of the maxillary anterior teeth and the maxillary central incisor, J. Prosthet. Dent 48 (1982) 15–22.
[6] U. Hasanreisoglu, S. Berksun, K. Aras, I. Arslan, An analysis of maxillary anterior teeth: facial and dental proportions, J. Prosthet. Dent 94 (2005) 530–538.
[7] V. Cesario, G.H. Latta, Relationship between the mesiodistal width of the maxillary central incisor and interpupillary distance, J. Prosthet. Dent 52 (1984) 641–643.
[8] H.M. Al-el-Sheikh, M.S. al-Athel, The relationship of interalar width, interpupillary width and maxillary anterior teeth width in Saudi population, Odonto-Stomatol. Trop. 21 (1998) 7–10.
[9] K.A. Al Wazzan, The relationship between intercanthal dimension and the widths of maxillary anterior teeth, J. Prosthet. Dent 86 (2001) 608–612.
[10] M.A. Abdullah, Inner canthal distance and geometric progression as a predictor of maxillary central incisor width, J. Prosthet. Dent 88 (2002) 16–20.
[11] E. Eslami, P. Zadparvar, H. Ansari Lari, A.H. Mirhadian, R. Sadr-Eshkevari, Correlation of maxillary anterior tooth width and outer intercanthal distance, Gen. Dent. 63 (2015) 39–42.
[12] N. Srimaneekarn, T. Arayapisit, O. Pooktuantong, H.R. Cheng, P. Soonsawad, Determining of canine position by multiple facial landmarks to achieve natural esthetics in complete denture treatment, J. Prosthet. Dent 127 (2022) 860–865.
[13] V.L. Gomes, L.C. Gonçalves, C.J. do Prado, I.L. Junior, B. de Lima Lucas, Correlation between facial measurements and the mesiodistal width of the maxillary anterior teeth, J. Esthetic Restor. Dent. 18 (2006) 196–205.
[14] P. Sinavarat, C. Anunmana, S. Hossain, The relationship of maxillary canines to the facial anatomical landmarks in a group of Thai people, J Adv Prosthodont 5 (2013) 369–373.
[15] F.M. Varjão, S.S. Nogueira, Intercommissural width in 4 racial groups as a guide for the selection of maxillary anterior teeth in complete dentures, Int. J. Prosthodont. (IJP) 18 (2005) 513–515.
[16] E.C. Parciak, A.T. Dahiya, H.S. AlRumaih, M.T. Kattadiyil, N.Z. Baba, C.J. Goodacre, Comparison of maxillary anterior tooth width and facial dimensions of 3 ethnicities, J. Prosthet. Dent 118 (2017) 504–510.
[17] Z.M. Isa, O.F. Tawfiq, N.M. Noor, M.I. Shamsudheen, O.M. Rijal, Regression methods to investigate the relationship between facial measurements and widths of the maxillary anterior teeth, J. Prosthet. Dent 103 (2010) 182–188.
[18] A. L-Kaisy N, B.T. Garib, Selecting maxillary anterior tooth width by measuring certain facial dimensions in the Kurdish population, J. Prosthet. Dent 115 (2016) 329–334.
[19] H. Özdemir, M. Köseoğlu, Relationship between different points on the face and the width of maxillary central teeth in a Turkish population, J. Prosthet. Dent 122 (2019) 63–68.
[20] K.L. Moore, T.V.N. Persaud, M.G. Torchia, The Developing Human, tenth ed., Saunders, Philadelphia, 2015, pp. 237–253.
[21] S. Tian, M. Wang, F. Yuan, N. Dai, Y. Sun, W. Xie, J. Qin, Efficient computer-aided design of dental inlay restoration: a deep adversarial framework, IEEE Trans. Med. Imag. 40 (9) (2021) 2415–2427.
[22] Y. Feng, B. Tao, J. Fan, S. Wang, J. Mo, Y. Wu, Q. Liang, 3D reconstruction for maxillary anterior tooth crown based on shape and pose estimation networks, Int. J. Comput. Assist. Radiol. Surg. (2023), https://doi.org/10.1007/s11548-023-02841-1. Epub ahead of print. PMID: 36754949.
[23] S. Tian, M. Wang, N. Dai, H. Ma, L. Li, L. Fiorenza, Y. Sun, Y. Li, DCPR-GAN: dental crown prosthesis restoration using two-stage generative adversarial networks, IEEE J Biomed Health Inform 26 (1) (2022 Jan) 151–160.
[24] H. Zhu, X. Jia, C. Zhang, T. Liu, ToothCR: a two-stage completion and reconstruction approach on 3D dental model. Advances in knowledge discovery and data mining: 26th Pacific-Asia conference, PAKDD, Chengdu, China, Proceedings, Part III (2022) 161–172.