Original research

Anatomic landmarks in the maxilla for guidance of anterior prosthetic teeth positioning

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ABSTRACT

Objectives: To obtain data supporting the establishment of bony anatomical parameters to guide the proper arrangement of anterior artificial teeth in the maxilla.

Methods: A total of 60 skulls with all permanent anterior teeth, Angle Class I molar relationship, overjet and overbite of up to 3 mm, and alignment between the maxillary central incisors were selected. Three measurements were obtained: (A) distance from the labial surface of the maxillary central incisors to the incisive foramen (IF) posterior wall, (B) distance from the IF posterior wall to the distal portion of the posterior nasal spine, and (C) width of the maxillary central incisors. Pearson's correlation test was applied to evaluate the correlations between the obtained measurements. The two-way analysis of variance was used to assess the influence of age and sex on measurements.

Results: There was no correlation between the distances A and B, or between B and C, and only a weak correlation was noted between measurements A and C. Age and sex did not interfere with the results of the measurements. Distance A exhibited a relatively constant value of 15 mm.

Conclusions: It was not possible to establish a mathematical correlation between the distance from the labial surface of the maxillary central incisors to the IF and the distance from the IF posterior wall to the posterior nasal spine. The 15-mm distance from the central incisors to the IF posterior wall could be an additional parameter to guide anteroposterior positioning of the maxillary anterior artificial teeth in cases of prosthetic rehabilitation. (Rev Port Estomatol Med Dent Cir Maxilofac. 2020;61(1):17-22)

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Referências anatómicas na maxila para guiar o posicionamento de dentes artificiais anteriores

RESUMO

Palavras-chave:
Posicionamento dentário
Prótese parcial fixa
Palato duro
Forame incisivo
Incisivo

Objetivos: Obter dados para estabelecer parâmetros ósseos a fim de guiar o posicionamento adequado de dentes artificiais anteriores na maxila.
Métodos: Um total de 60 crânios com todos os dentes permanentes anteriores, relação molar Classe I Angle, overjet e overbite até 3 mm e alinhamento entre os incisivos centrais superiores foi selecionado. Três medições foram feitas: (A) distância entre a superfície labial dos incisivos centrais superiores à parede posterior do forame incisivo (FI), (B) distância entre a parede posterior do FI à porção distal da espinha nasal posterior e (C) largura do incisivos centrais superiores. O teste de correlação de Pearson foi aplicado para avaliar as correlações entre as medidas obtidas. A análise de variância de dois fatores foi utilizada para avaliar a influência da faixa etária e do sexo nas medidas realizadas.
Resultados: Não houve correlação entre as distâncias A e B, e entre as medições B e C. Houve fraca correlação entre as medidas A e C. A idade e o sexo não interferiram nos resultados das medidas. A distância A exibiu um valor relativamente constante, de 15 mm.
Conclusões: Não foi possível estabelecer uma correlação matemática entre a distância da superfície labial dos incisivos centrais superiores ao FI e a distância da parede posterior do FI à espinha nasal posterior. A distância dos incisivos centrais até a parede posterior do FI em torno de 15 mm poderia ser um parâmetro adicional para guiar o posicionamento ântero-posterior dos dentes artificiais anteriores superiores em casos de reabilitação protética.
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Introduction

The arrangement of the front teeth in prosthetic replacement remains a challenge for most clinicians, and reliable anatomical parameters are essential to plan the face contour reconstruction.[1,2] In the case of teeth absence, the maxillary alveolar ridge undergoes intense resorption, with bone remodeling taking place in the palatine and apical directions.[2] Dental absence and bone support resorption in the maxillary anterior region result in lip support loss; consequently, aesthetic and phonetic changes are inevitable.[1,2]

Soft-tissue-based landmarks have been extensively described in the literature, and the incisive papilla (IP) has been pointed out as an important anatomical reference.[3-7] However, despite having a constant position, the IP is commonly found buccally relocated and/or with a rounded shape in atrophic alveolar ridges due to teeth loss,[8,9] thus compromising its reliable use as a reference for determining the position of the artificial incisor prosthesis.[3,4,8,10,11]

On the other hand, the incisive foramen (IF), an opening in the bone of the hard palate located immediately under the IP and behind the incisors, is stable even in the context of ridges with extensive bone resorption, regardless of teeth presence or absence.[12-14] This anatomical stability has justified its use in studies involving processes such as morphological evaluations of palatine sutures as anatomical references in anesthesia innervation coming from the palatal foramen, assessments of facial growth, and examinations of the spatial orientation

of upper incisor implant replacement.[15-18] Prior biometric and linear measurements have shown that this anatomical structure is reliable.[12,18-20]

The premaxilla is the first palate portion to fuse in the seventh week of uterine life.[21] It is a stable area in adults, with regular growth occurring during its development.[21,22] Since the IF is clearly identifiable in computer tomography, this anatomical landmark could be a pertinent reference point for proper maxillary incisor arrangement.

The objective of this study was to obtain data supporting the establishment of bony anatomical parameters to guide the proper arrangement of anterior artificial teeth in the maxilla. The following hypothesis was tested: reliable measurements of the maxilla can be obtained using the IF in fully dentate dry skulls with an Angle Class I molar relationship and suitable overjet and overbite.

Material and methods

This research received institutional review board approval. The authors used a dry skull collection of the Department of Orthodontics at the Federal University of Bahia for the purposes of this ex-vivo study. The initial study sample included 62 skulls. Inclusion criteria were an identified cause of death, presence of all permanent anterior teeth, Angle Class I molar relationship, overjet and overbite of up to 3 mm, alignment between the maxillary central incisors, and absence of any

hard tissue pathology in the maxillary anterior region. After a sample exam, two skulls were excluded due to not meeting all inclusion criteria.

Study measurements were performed by two previously calibrated independent observers, directly on the dry skulls, using the same digital caliper (Mitutoyo, Kawasaki, Japan). All steps were performed with an accuracy of 0.01 mm.

The measurements were performed according to the following anatomical landmarks: 1) Measurement A: The distance from the gingival third of the labial surface of the maxillary central incisors (LS-MCI) to the IF posterior wall (Figure 1); 2) Measurement B: The distance from the IF posterior wall and the distal portion of the posterior nasal spine (PNE) (Figure 2); 3) Measurement C: The width of the maxillary central incisors (W-MCI) (Figure 3).

The first observer measured all 60 skulls. To evaluate intraexaminer reliability, the measurements were repeated in 20% of the sample, randomly selected, with a two-day interval. The second observer, who was not present during the first stage, measured, with the same caliper, 20 skulls (33.33% of

Figure 3. Measurement C: width of the maxillary central incisors

the first stage). A paired *t*-test revealed no significant differences between the intra- and interexaminer measurements.

Normal distribution corroboration using the Lilliefors test verified the normality of all sample groups. A paired *t*-test evaluated the degree of intra- and interexaminer agreement. Pearson's correlation test was applied to evaluate the correlations between the obtained measurements. The reference values were interpreted as follows: 0.8 to 1.0 = strong positive relationship; 0.6 to 0.8 = moderate positive relationship; 0.2 to 0.6 = weak positive relationship; –0.2 to 0.2 = no relationship; –0.6 to –0.2 = weak negative relationship; –0.8 to –0.6 = moderate negative relationship; –1.0 to –0.8 = strong negative relationship.

A two-factor analysis of variance (ANOVA) determined whether differences in age or sex interfered with the measurement results. The level of significance for all statistical tests was predetermined at 5%. The Minitab 17 statistical software program (Minitab, LLC, State College, PA, USA) was used to analyze all tests.

Figure 1. Measurement A: distance from the labial surface of the maxillary central incisors to the IF posterior wall

Results

The final sample consisted of 60 dry skulls, whose death occurred at ages ranging between 16 and 64 years and a mean age of 28.4 ± 12.3 years. Mean and standard deviation (SD) values for all samples, as well as 95% confidence intervals (CIs), are presented in Table 1. A coefficient variation analysis revealed that all three measurements (i.e., A, B, and C) and age were homogeneous (< 25%).

Descriptive results were obtained (Tables 2 and 3) by separating the skulls into the following groups: G1, younger than 22 years (n = 21); G2, 22 to 30 years old (n = 20); G3, older than 30 years (n = 19); G4, all females (n = 25); and G5, all males (n = 35). However, age and sex did not interfere with the results of the measurements A (age, p=0.833; sex, p=0.400), B (age, p=0.065; sex, p=0.152), and C (age, p=0.165; sex, p=0.564).

There were no correlations between the distances A and B or between B and C, and only a weak correlation was noted between measurements A and C (Table 4). Measurement A exhibited a relatively constant value of 15 mm for all groups (Figure 4).

Figure 2. Measurement B: distance from the IF posterior wall to the distal portion of the posterior nasal spine

Table 1. Measurements A, B, C and age

Statistics	Measurement A	Measurement B	Measurement C	Age (years)
Mean (mm)	15.161	42.015	16.876	28.483
Standard deviation (SD)	2.085	2.9326	1.0311	12.2923
Coefficients of variation(CV)	0.137524	0.069799	0.061099	0.431566
95% CI	(14.6; 15.7)	(41.3; 42.8)	(16.6; 17.1)	(25.3; 31.7)

Table 2. Means and standard deviation of measurements (mm) in age groups and F-statistics in ANOVA

Measurements	Groups			
	G1: < 21 years Mean (SD)	G2: 22-30 years Mean (SD)	G3: > 30 years Mean (SD)	F-statistics p value
A	15.084 (1.754)	15.078 (2.639)	15.334 (1.852)	F = 0.183 p = 0.833
B	40.788 (3.513)	42.462 (2.482)	42.900 (2.281)	F = 3.029 p = 0.056
C	16.599 (0.984)	16.813 (1.061)	17.250 (0.988)	F = 1.859 p = 0.165

Level of significance: p<0.05

Table 3. Means and standard deviation of measurements (mm) in sex groups and F-statistics in ANOVA

Measurements	Groups		
	G4: Female Mean (SD)	G5: Male Mean (SD)	F-statistics p value
A	15.399 (2.063)	14.991 (2.113)	F = 0.721 p = 0.40
B	41.341 (3.079)	42.495 (2.771)	F = 2.112 p = 0.152
C	16.736 (1.126)	16.977 (0.961)	F = 0.336 p = 0.165

Level of significance: p<0.05

Table 4. Correlation between measurements.

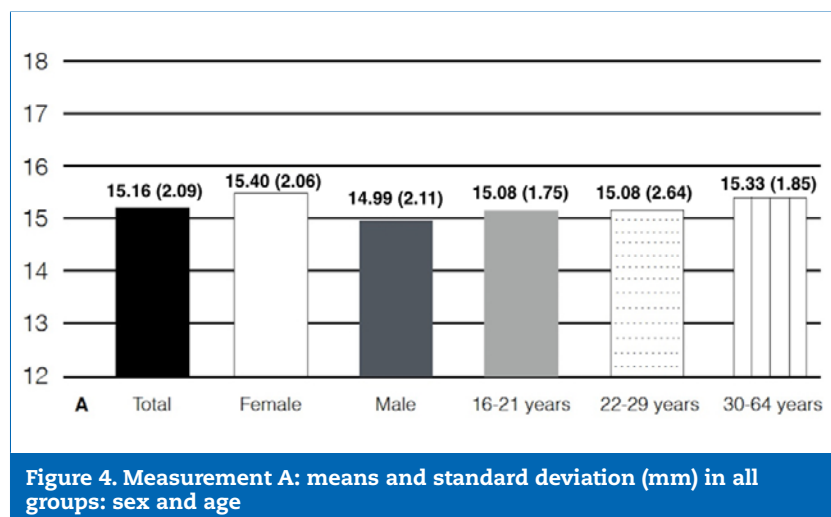| Variable	Pearson's correlation coefficient
A x B	-0.094
A x C	0.253
B x C	-0.086

Figure 4. Measurement A: means and standard deviation (mm) in all groups: sex and age

Discussion

Since the artificial maxillary anterior teeth set aesthetic, phonetic, and functional patterns, determining and maintaining their proper position is essential for adequately constructing both tooth-supported and implant-supported prostheses.[6] However, the facial contours of edentulous patients offer only indirect indications for artificial anterosuperior teeth arrangement.[6] Furthermore, the use of references such as the smile line and the distance between mouth corners reflects significant variation and does not facilitate precise or reliable positioning of artificial teeth.[6]

A study[23] attempted to establish the ideal oral cavity anatomical structures with which to locate the palatal foramen and reported linear distances between the front teeth and the landmark in question but did not provide data about the IF. Those authors, using computed tomography (CT) images, questioned the use of dry skulls in studies due to the frequent lack of information available about sex and the difficulty with assessing angular measurements, leading to a low level of accuracy. In our study, the whole sample had been classified and identified by both sex and age at the time of death. Also, our study considered the previous data and involved only direct linear measurements.

Another study[18] assessed 34 CT skull scans and found that sex, age, and the presence or absence of teeth did not affect the anatomy of the nasopalatine canal, including the IF. However, these authors reported the need for studies with larger samples to assess the influence of these factors better. Similarly, we herein did not observe any differences in bone and dental measurements when considering sex and age. It should be noted that the sample size of our study (n = 60 skulls) was almost twice as large as that study's.

Many authors[12,14,19,20,24,25] reported no statistical differences in the anatomy of the IF when comparing toothed and edentulous samples. Conversely, in one study,[13] the appearance of an enlarged incisive canal was observed after the teeth were lost; however, the posterior wall of the incisive canal remained relatively stable. It is noteworthy, though, that these results were achieved using a heterogeneous sample in which no pairing for comparison of anatomical changes was conducted. Therefore, the findings could be attributed to anatomical variations of the evaluated structure.

In the current study, both age and sex were not statistically significantly correlated with the measurements obtained. In another study,[19] the IF exhibited no statistical differences in terms of sex, age, or the presence or absence of the central incisors. A small increase in the IF in males was noted. Elsewhere, two studies[8,20] observed differences between males and females in terms of the size of the IF and the dimensions of the remaining buccal bone in edentulous patients. However, these authors did not identify significant differences regarding age.

No correlations were observed between the measurements A, B, and C (Table 4), so it was not possible to establish an approximate mathematical correlation between them. Nevertheless, the high consistency level obtained from measurement A, exhibiting widely uniform and constant results for all groups (Figure 4), suggests that the 15-mm distance from the central incisors to the IF posterior wall could be an additional parameter to help guide anteroposterior positioning of superior anterior artificial teeth in cases of prosthetic rehabilitation. Moreover, these data exhibited constant means independently of sex and age. The clinical relevance of this study was the presentation of an additional measurement to be used in planning prosthetic replacements of edentulous anterior teeth in the maxilla with extensive alveolar bone resorption, which should be incorporated not as a fixed measurement but rather as a reference value to assist clinicians.

One particular limitation of this study was that the anteroposterior measurements were not purely horizontal because the dry skull points used were not positioned in the same axial plane. Therefore, other studies should test the correlation between measurements A and B considering perpendicular projections of the points to only one axial plane. This assessment is possible using CT images and could allow a direct application in the clinic. Finally, because the study sample was nonprobabilistic, covering only one specific origin, caution should be taken when generalizing the findings to larger populations.

Conclusions

The following conclusions can be drawn from this study:

1. It was not possible to establish a mathematical ratio between the distance from the labial surface of the maxillary central incisors to the incisive foramen and the distance from the incisive foramen posterior wall to the posterior nasal spine because there is no correlation between these measurements when obtained directly from dry skulls.
2. The 15-mm distance from the central incisors to the incisive foramen posterior wall could be an additional parameter to guide the anteroposterior positioning of the maxillary anterior artificial teeth in cases of prosthetic rehabilitation.
3. Age and sex did not interfere with the anatomical distances from the labial surface of the maxillary central incisors to the IF posterior wall, from the IF posterior wall to the distal portion of the posterior nasal spine, nor with the width of the maxillary central incisors.
4. Other studies are necessary to test the correlation between these measurements in only one axial plane using maxillary CT images.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflict of interest

The authors have no conflicts of interest to declare.

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