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Distance of the alveolar crest to infraorbital foramen in dentulous and total edentulous maxillae: a reference to the anterior superior alveolar nerve anesthesia

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ABSTRACT

Introduction: The technique of dental anesthesia of the anterior superior alveolar nerve (ASAN) is complex and may become more difficult in total edentulous patients, since the reabsorption of the alveolar process and subsequent decrease in face height alters the local morphology and topography, including the anatomical accidents of reference for this technique. The aim of this study is to determine if there is a statistically significant difference between the vestibular alveolar crest of the first upper premolar to the center of the infraorbital foramen (IOF) in skulls with dentulous and edentulous maxillae. **Material and Methods:** 30 adult skulls, divided into 15 dentulous skulls and 15 senile edentulous skulls, were collectedfrom the human Anatomy Laboratory of the Federal University of Uberlandia. The distance between the alveolar bone crest of the first upper premolar from the center of the IOF in the maxilla was measured with a digital caliper. **Results:** Measurements between these distances revealed that the averages between dentulous and edentulous maxillae presented differences of 4.0 mm (right side) and 4.2 mm (left side) in distance. In the dentulous maxillae, the sides had a mean difference of 0.4 mm and, and the sides of the edentulous maxillae showed an average difference of 0.2 mm. The differences were statistically significant between the dentulous and edentulous skulls, but not within their respective antimeres. **Conclusion:** We concluded that for a safe clinical performance of the ASAN anesthesia technique in the IOF region, the penetration of the needle should be 4 mm smaller in the edentulous patients when compared with the total dentulous, providing safety for the technique and comfort for the patient.

Keywords: dentulous maxillae; edentulous maxilla; anterior superior alveolar nerve; dental anesthesia

INTRODUCTION

The infraorbital foramen is essential as it transmits nervous and vascular branches to the face of the infraorbital nerve and artery, respectively [1]. From the surgical point of view, this foramen is nearby dangerous regions, such as the bucal, orbital and nasal. As such, it is essential to know its exact location for better execution of surgical techniques [2].

The infraorbital nerve (ION) is a branch of the maxillary nerve as it reaches the inferior orbital groove through the inferior orbital fissuraorbital groove, situated at the floor of the orbital cavity. Then, nearby its exit through the IOF, the ION gives the anterior superior alveolar nerves (ASAN). These

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branches descend to reach the incisive and canine teeth from the maxilla, thereby, innervating them. They are often injected with anesthetic solutions for the dental treatment of the aforementioned teeth [3-6].

The first step to perform this technique is the prior anatomical knowledge of the location of the muco-vestibular fold in the vestibule of the anterior region. The needle can be introduced at the level of the upper teeth, from the second premolar to the upper central incisor. The path from the needle penetration is towards the IOF, which is located below the infraorbital margin [7].

The IOF is usually located 0.5 to 1.0 cm below the infraorbital margin [8, 9] in the canine fossa region of the maxilla and its anatomical features have important implications for local anesthetic planning and surgical, as previously reported [10].

Conventionally, the ION should be blocked in ASAN anesthetic blocks [11], however, the success rate of this technique is variable, due to possible anatomical changes in the height of the medium third of the face, considering the distance of the vestibular alveolar crest to the IOF, in the cases of alveolar bone resorption and remodeling as a consequence of the loss of teeth, a very common physiological process that occurs in edentulous patients. It is also a fact that may contributes to the failure of the anesthetic block because the loss or difficult to find the reference anatomical structures in the face which are necessaries to performance of the anesthetic procedure.

The mean distance between the IOF from the infraorbital margin ranges from 6.5 to 8.5 mm, while its distance from the alveolar process of the maxilla ranges from 25 to 27 mm [12], with no statistical differences between side and gender [10]. However, there is no literature report of this distance of total edentulous patients, which presents severe resorption of the alveolar process and often causes in a clinically atrophic maxillae.

The aim of the present study is to determine the mean distance and if there is statistically significance difference in the distance of the vestibular alveolar crest of the region of the upper first premolar until to the center of the IOF in the dentulous maxillae compared to the edentulous maxillae.

MATERIAL AND METHODS

The skulls studied herein are part of the study and research material from the Department of Human Anatomy of the Federal University of Uberlândia. This study was conducted in agreement with the Brazilian law number 8.501 published in 1992 and the declaration of Helsinki, which deals with the use of corpse or pieces anatomical structures for the purpose of studies or scientific research.

Figure 1: Dentate skull and total edentulous skull.

Thirty skulls were used in the present study, which comprised a sample of 60 maxillae, and these were divided into a two groups with 15 dentulous skulls and 15 total edentulous skulls (Figure 1), being thus a total of 30 dentulous maxillae and 30 total edentulous maxillae, when the antimeres are considered. The skulls are from adult and senile individuals, which are respectively dentulous and edentulous, regardless of gender or race

Four variables were studied; they are the dentulous and edentulous maxillae, and the right and left maxillae, which were corresponding to the respective antimeres. In these samples, it were determined the mean distances and their relations between the crest of the vestibular alveolar process in the region of the upper first premolar tooth and the center of the IOF (Figure 2). Measurements were performed with a digital caliper (Mitutoyo MTI Corporation, Crystal Lake, Illinois, USA) and are expressed as millimeters (Figure 3).

The collected data were submitted to the Shapiro-Wilk and Levene test to determine the normality of the samples. The data were then submitted to the two-way ANOVA test (2x2) followed by the Tukey test, and a value of $p < 0.05$ was considered statistically significant.

RESULTS

The data were approved in the analysis of normality by the Shapiro-Wilk test (P = 0.456) and test of equality of variance (P = 0.860).

The averages of the distance between the vestibular margin of the alveolar bone crest of the upper first premolar and the center of the IOF of each maxilla studied (dentulous and edentulous groups) and the right and left sides of the skull varied from 28.9 to 33.3 mm (Table 1).

Figure 2: Black line indicating the measured distance from the center of IOF to the alveolar bone crest in dentulous and edentulous skulls.

The values between dentulous and edentulous skulls presented mean differences of 4.0 mm (right maxilla) and 4.2 mm (left maxilla). Regarding to right and left maxillae, the antimeres of the dentulous skulls had a mean difference of 0.4 mm, while this value between the antimeres of the edentulous skulls was 0.2 mm.

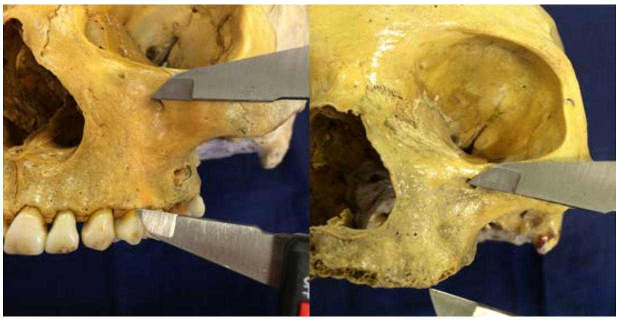

Figure 3: Measurement of the distance between the center of the IOF and the alveolar bone crest (upper first premolar region) performed with a digital caliper in dentulous and edentulous skulls.

Statistical analysis under ANOVA and Tukey test presented a statistically significant difference ($p<0.001$) between the dentulous and edentulous maxillae variables, for that values previously cited of 4.0 e 4.2 mm, respectively to the right and left maxillae. Therefore, the distance between the anatomical structures of reference to the anesthetic technique previously described was greater statistically in the dentulous maxillae, when compared to edentulous.

However, there were no statistical differences between the different sides or antimeres in the skulls of the same group (dentulous or edentulous) (Table 2).

Table 1: Mean distances of the IOF to alveolar bone crest in dentulous and edentulous maxillae, in both sides, ranging of 4.0 to 4.2 mm.

Maxilla	Right	Left
Dentate	32.9 mm	33.3 mm
Edentulous	28.9 mm	29.1 mm

Table 2: Mean and standard deviation (±) of the distance between IOF to alveolar bone crest of the upper first premolar. *represents statistically significant difference between dentulous and edentulous maxillae ($p < 0.05$).

Maxilla	Side	
	Right	Left
Dentate	32.9±2.9	33.3±2.9
Edentulous	28.9±2.9*	29.1±2.9*

DISCUSSION

The need for knowledge of topographic anatomy of the skull in total edentulous patients is real, as we are faced daily with these patients in the dental office. The loss of height of the middle and lower thirds of the face is an important factor to be considered during the physical examination and the clinical approach when dealing with total edentulous patients. The study of dentulous and total edentulous skulls provides a theoretical and structural basis for the clinical performance in these different patients, thus, the standardization of palpable anatomical reference points and the determination of a relative average distance between the anterior margin of the alveolar bone and the IOF in different maxillae (dentulous and edentulous) will anatomical parameters for the safe and effective anesthetic blockade of ASAN.

In world literature, the works regarding the topographic location of IOF, the ION, and ASAN in the total edentulous patients or total edentulous skulls compared with that dentulous are scarce, as well as their relation with the alveolar bone height.

The relationship between dental elements loss, the resorption of the alveolar process, the loss of maxilla height and the location of the anatomical reference points for performing the ASAN anesthesia technique in total edentulous patients is a necessity for the dentist.

Based on these facts, the present study performed measurements between the IOF and the margin of the vestibular alveolar bone crest of the first upper premolar in dentulous and edentulous skulls to determine the location and mean distance between these anatomical points, as well as the possible differences between these distances.

This information may provide details of extreme value and importance for the execution of the technique for ASAN anesthetic block in these different patients, elucidating and eliminating possible difficulties and thus facilitating technique performance for both for both the dentistry student and for the dental surgeon.

The importance of ION and its location in relation to alveolar bone also extends to the area of maxillofacial surgery, in cases of orbital floor reconstructions and Caldwell-Luc access [11-19], and to the surgery area which has previously been suggested to block ION prior to the nasociliary nerve in nasal reconstruction surgeries [13].

In this work, the skulls genders were not considered, since they did not present statistical differences regarding the position of the IOF, since this has been vastly reported in the literature (generally, in the anterior face of the maxilla at about of 7 mm to until 8.5 mm in average distance below of the infraorbital margin) [20, 21].

Furthermore, the IOF has a mean diameter of 2.72 mm [22] and is usually located on the anterior surface of the maxilla in a vertical and longitudinal direction to the first upper premolar tooth [9, 10], although it can point towards the second premolar [22]. Despite that, the first upper premolar is the best reference for dental anesthetic procedures. The precise location of the IOF may also present a slight anatomical variation according to the study population, since there may be differences in the biotype and craniofacial morphology [23].

This may also explain the differences between our results, which revealed averages of 32.9 to 33.3 mm distance between the IOF and the alveolar bone margin in dentulous skulls, in agreement to the findings of Caldeira et al. (2008), who related the means varying from 26.1 to 28.5 mm in dry skulls from Brazil.

The presence of multiple infraorbital foramina adjacent to the IOF has been previously reported [21], being curiously the highest frequency of this anatomical variation found in Mexicans [24], which can lead to success of the ION anesthesia technique and ASAN block, however, the authors argue the hypothesis that the presence of accessory infraorbital foramina could result in a partial block of the ASAN [10]. The presence of an accessory infraorbital foramen, such as a double foramen, was also revealed by Dixit et al. (2014) [9].

The IOF is an important point of reference for needle approach during ASAN anesthesia technique, since the scientific literature reported a variation of NASA's origin of the ION at a distance from the opening of the IOF ranging from 5 to 15 mm and, in rare cases, greater than 20 mm [25].

From the clinical point of view, these anatomical variations constitute a challenge that contributes to the complexity of the dental anesthesia technique. Thus, the dentistry student or the clinical dentist must understand facial anatomy - the topographic aspects and palpatory aspects - in order to precisely locate the IOF and successfully performing the anesthesia, thus providing a better healthcare service.

Our results did not revealed statistical differences between the right and left sides in both dentulous and total edentulous skulls. This was already expected, since the sides of the same patient have very similar dimensions.

However, the differences were significant between dentulous and total edentate skulls, results already expected due to the severe bone resorption of the alveolar process caused by dental losses. This is further validated due to the physiological bone aging, which contributes to the progression of structural alterations, especially the decrease of height in the maxilla.

In order to achieve ASAN block in a total edentulous patient, it can be considered that, according to the results revealed in this study, the penetration depth of the needle should be on average 4.0 mm lower when compared to a dentulous patient ($p < 0.05$).

This may provide greater safety to the dental surgeon and, especially, to the dentistry student during the care of dentulous and edentulous patients. It is also important to note that the main clinically notable changes in the senile and total edentulous patients are the loss of height in the middle and lower face regions and the increase in the depth of the anterior face of the maxilla in the infraorbital region [26], without changes in the location of anatomical reference points to the IOF anesthetic technique.

The middle third of the face is formed by the maxilla, medially, and by the zygomatic bone, laterally. It was clearly demonstrated the retraction of the middle third of the face during aging, even in dentate patients [27], however, the rate of bone resorption in this region is not uniform [28]. The maxilla is more susceptible to bone loss caused by aging than the zygomatic bone [28]. This modifies the angle of the middle third of the face, relative to the horizontal plane, by up to 10º, when compared with younger individuals [26, 29].

These structural changes caused by aging are more prominent near the orbital margins and the piriform opening of the maxilla, which reach peak projection in adulthood and progressively loses volume [29, 30].

The maxilla differs in origin and function from the other bones that forms the orbital cavity, as it is a bone that makes up for the support of the teeth. In young people the maxilla expands to accommodate the growth and development of the dentition inside and the eruption of the permanent dentition leads to a greater reduction of the volume of the maxilla, especially in its lower part [26].

The lack of bone stress, associated to the tooth loss, can be a contributing factor to bone loss in these areas. In addition, it is reasonable to say that alveolar bone is a functional bone for which all occlusal force is dissipated and loss of dental elements decreases bone stress, that is, the relation between bone function and remodeling, resulting in its progressive resorption. In a morphophysiological analysis, skull aging and total tooth loss are two factors that have a close relationship and lead to a severe decrease in the facial bone structure [26]

As previously stated, these regions encompass the canine fossa, usual location of the IOF and a reference point for ASAN anesthesia and this may explain the results observed herein for the distances between the IOF and the vestibular alveolar bone crest among toothed and edentulous skulls.

CONCLUSION

Our results led us to conclude that the needle penetration during the infraorbital nerve anesthesia technique to block the anterior superior alveolar nerve in total edentulous patients should be 4 mm smaller depth in comparison to dentulous patients.

In addition, this information plays an important role in the prevention of iatrogenic injuries during anesthetic procedures and allows the dentist to perform satisfactory and safe procedures for the infraorbital nerve and the anterior superior alveolar nerve at the level of the infraorbital foramen, which range from dental anesthesia to surgical procedures, both in dentulous and total edentulous patients.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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RESUMO

Distância da crista alveolar ao forame infra-orbital em maxilas dentadas e edentadas totais: uma referência para a técnica de anestesia do nervo alveolar superior anterior

Introdução: A técnica de anestesia odontológica do nervo alveolar superior anterior (NASA) é complexa e pode se tornar mais difícil nos pacientes edentados totais, uma vez que, a reabsorção do processo alveolar e consequente diminuição da altura dos terços médio e inferior da face, altera a morfologia e topografia local, incluindo os acidentes anatômicos de referencia para esta técnica. O objetivo deste estudo é determinar se existe diferença significativa entre a margem óssea alveolar vestibular do primeiro pré-molar superior até o centro do forame infra-orbital (FIO), em maxilas de crânios dentados e edentados totais. Material e Métodos: Foram utilizados 30 crânios adultos e senis, sendo 15 crânios dentados e 15 crânios edentados totais, do acervo do laboratório de anatomia humana da Universidade Federal de Uberlandia. Resultados: As mensurações entre estas distancias revelaram que as médias entre as maxilas dentadas e edentadas apresentaram diferenças de 4,0 mm (antímero direito) e 4,2 mm (antímero esquerdo) em distância. Nas maxilas dentadas, os antímeros apresentaram diferença média de 0,4 mm e, nas maxilas edentadas, os antímeros apresentaram diferença média de 0,2 mm. As diferenças foram significativamente estatísticas entre os crânios dentados e edentados totais, mas não entre nos seus respectivos antímeros. Conclusão: Concluímos que para uma realização clínica segura da técnica de anestesia do NASA, na região do FIO, a penetração da agulha deve ser 4 mm menor no paciente edentado total, em relação ao dentado total, proporcionando segurança para a execução da técnica e conforto para o paciente.

Palavras-chave: maxila dentada; maxila edentada; nervo alveolar superior anterior; anestesia odontológica.