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ORIGINAL RESEARCH

Evaluation of dimensions of the distal alveolar bone of the second molar by cone beam after extraction of third molars

Evaluación de las dimensiones del hueso alveolar distal del segundo molar a través de cone-beam post-extracción del tercer molar

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ABSTRACT

Several studies have assessed the quality of periodontal tissues adjacent to the second molar after extraction of third molars using clinical assessment and radiographs. In clinical practice, the space occupied by these molars is used to perform distalizing movements and tissue integrity is a condition to do it, so it is necessary to evaluate with suitable methods such as digital volume tomography alveolar bone quality, before and after the removal of third molars. The aim of the study was to evaluate through cone beam dimensions the distal alveolar bone of the second molar after third molar extractions in patients undergoing orthodontic treatment. A quasi-experimental study was implemented with a six months follow up in patients with orthodontic treatment that attended the post-graduate clinic of the University of Cartagena. The sample consisted of 128 molars of 32 individuals treated with fixed appliances. Bone dimensions behaved as follows: height was 3.44 mm T0, T1 of 3.96 mm and 3.44 mm in T2; the thickness was 2.90 mm T0, T1 was 2.79 mm and 3.37 mm T2; T0 width was 15.58 mm, 15.50 mm in T1 and T2 of 15.19 mm. The alveolar process can recover its dimensions after extraction thanks to dental movements generated by orthodontics thus maintaining a stability which results in periodontal health.

RESUMEN

Diversos estudios evalúan la calidad de los tejidos periodontales adyacentes al segundo molar después de la extracción de los terceros molares utilizando como método la valoración clínica y las radiografías. En la práctica clínica, el espacio ocupado por estos molares se usa para realizar movimientos de distalización y la integridad de los tejidos, es una condición para poder realizarlo, por lo que es necesario evaluar con métodos idóneos, como la tomografía volumétrica digital, la calidad del hueso alveolar, antes y después de la extracción de los terceros molares. El objetivo de la investigación fue evaluar a través de *cone-beam* las dimensiones de hueso alveolar distal del segundo molar después de la extracción de los terceros molares en sujetos sometidos a tratamiento de ortodoncia. Se implementó un estudio cuasiexperimental con seguimiento a seis meses, en pacientes con ortodoncia fija; que acuden a la Clínica de Postgrado de la Universidad de Cartagena. La muestra fue constituida por 128 molares de 32 individuos tratados con ortodoncia fija. Las dimensiones óseas se comportaron de la siguiente manera, la altura en T0 fue de 3.44 mm, en T1 de 3.96 mm y en T2 de 3.44 mm; el grosor en T0 fue de 2.90 mm, en T1 fue de 2.79 mm y en T2 de 3.37 mm; la anchura en T0 fue de 15.58 mm, en T1 de 15.50 mm y en T2 de 15.19 mm. El proceso alveolar puede recuperar sus dimensiones después de una extracción gracias a los movimientos dentales generados por ortodoncia, manteniendo una estabilidad que se traduce en salud periodontal.

Key words: Alveolar bone, third molar, orthodontics, tooth movement, tooth extraction, computed tomography cone-beam.
Palabras clave: Proceso alveolar, tercer molar, ortodoncia, movimiento dentario, extracción dental, tomografía computarizada de haz cónico.

INTRODUCTION

The third molars are the teeth that frequently present congenital absence and impaction. They are present in 90% of the population and at least 33% of them presents an impacted third molar, and moreover, they represent 98% of all impacted teeth. The mandibular third molar presents a greater frequency of impaction and the incidence varies from 9.5 to 68 per cent in different populations.[1] The difficulty in third molar eruption, in particular of the lower, is due to their late formation and to the phylogenetic evolution of the mandible, which gives as a result a lack of available space for the molars to erupt normally. So far there

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is no model that allows us to reliably predict whether eruption or retention of the third molar will occur.[2]

In a study by Chaparro Avendaño et al., that analyzed the morbidity of the third molars, they reported that the main reason for extraction was the indication by the orthodontist (40.5%), followed by prophylactic indication (39.5%). The presence of clinical manifestations was an indication for extraction in 20% of cases.[3]

One of the problems that the orthodontist faces is the compensation of malocclusions of skeletal or dental origin, which until a few years ago, was one of the indicators of premolar extractions. In recent times orthodontists have increasingly resorted to distalization as an alternative solution to this anomaly, so that old techniques have been revitalized and also, new techniques arise proving to be very effective in responding to the scientific and technical development.[4,5] Given that these new techniques prevent bicuspid extractions, the space occupied by the third molars is required by the distalization of the upper or the lower arch depending of the malocclusion.[6]

On the other hand most of scholars such as Metteset al. (2005), Richardson (1989), Mr Lindqvist & Thilander (1982), Carbonell (1999), Harradine et al (1998) and many others, have come to the conclusion that «the removal of the third molars to reduce the degree of overcrowding, cannot be justified». However, authors such as Sato, Ricketts and Zachrisson are supporters of the preventive removal of the third molars due to their importance as a factor in relapse of orthodontic treatments, especially of incisor crowding; and particularly in the orientation of Sato, due to their importance in the development of posterior discrepancy, which has been observed to be a very important etiopathogenic factor in the development of skeletal malocclusions such as class III and open bites.[7] Some authors report that periodontal tissues in general do not present significant changes with third molar extractions and that in many cases there is evidence of an improvement of the periodontal health status of the tissues adjacent to the second molar,[8,9] but that the procedure represents a risk in patients with healthy periodontium.[10]

MATERIAL AND METHODS

This was a quasi-experimental study with a follow-up cohort of six months. The population was composed of all patients that attended the Postgraduate Clinic of Orthodontics at the University of Cartagena with fixed appliances during the period between February 2013 and December 2013. The sample was composed of 128 molars of 32 individuals treated with fixed appliances. The patients had voluntarily agreed to take part in the project by signing an informed consent. The size of the sample was selected using the STATA 12.0 Software, with a type 1 error of 5% and a power of 80%; average bone height in T0 was 3.1 with a standard deviation of 0.8; average height in T1 was 2.8 and diversion of 0.8, preventing a 10% loss of the sample.

Individuals were selected in a non-probabilistic manner considering the following criteria: individuals treated with fixed appliances at the Faculty of Dentistry of the University of Cartagena, subjects with upper or lower impacted third molars, subjects in whom distalization movements would be performed during the orthodontic treatment; participants with a range of age between 15 to 45 years. In order to restrict the entry of sample units that could confuse the results interpretation it was decided to exclude patients who presented: periodontal disease in the area of the second molars before starting orthodontic treatment, patients who suffered from any systemic disease, patients who smoked; patients with incomplete root formation of the second molar and women in state of pregnancy.

The sample was selected in a non-probabilistic manner taking into consideration that all patients fulfilled the inclusion criteria and signed the informed consent. Finally the patients were given an order to perform a CBCT scan in the Coides Radiological Center (Cartagena, Colombia). After the CT scans were obtained, they were coded as well as the measurement instrument and the envelope in which all documents of the patient were saved.

A properly standardized examiner, using a Toshiba Satellite MC45 computer and a Genius DM03003 mouse, performed the measurement. The variables width, height and thickness were measured as follows:

- **Bone width:** labio-lingual distance of the alveolar ridge distal to the second molar. The reference point in which the measurement was obtained was half the distance from most coronal point in the bone crest to the apex of the distal root of the second molar. The measurements were performed in the bone distal to the second molar before (T0), eight days (T1) and six months (T2) after the extraction of the third molar.
- **Bone height measurement:** it was measured from the amelocementary line to the most coronal edge of the ridge of the alveolar bone distal to the second molar. To this end, we conducted a sagittal slice

through the developmental groove of the second molar. The measurements were made in the bone distal to the second molar before (T0), eight days (T1) and six (T2) months after the extraction of the third molar.

- **Bone thickness:** it was measured in the box of the sagittal view. Length measured from the alveolar bone distal to the second molar to the alveolar bone mesial to the third molar. The long axis of the second molar was used as reference line. It was obtained by drawing a line tangent to the occlusal plane of the tooth and an apical perpendicular. Once the long axis of the tooth was determined, a perpendicular line to the long axis was drawn, at the midpoint of the distance of the coronal edge of the alveolar crest distal to the second molar to the apex of the distal root of the second molar. On this line the measurement was performed. The measurements were made in the bone distal to the second molar before (T0), eight days (T1) and six (T2) months after the extraction of the third molar.
- **Third molar surgery:** All surgeries were performed by the same operator duly standardized on the surgical technique. In all surgeries previous asepsis procedures were performed in the oral cavity. Local anesthesia with lidocaine -epinephrine at 2% was placed for the third molars. All the incisions were made with a #3 scalpel handle and a #15 scalpel blade. For the lower third molars, a modified Kruger incision was made and a partial Neumann incision for the upper molars. In both arches, a full thickness flap was conducted. Osteotomy was performed with a NSK brand low speed piece and a 703 bur. External cooling was applied with 80 cm^3 physiological serum with a syringe of 20 cm^3.

  Luxation and avulsion of the molars was performed with a straight elevator and finally, the alveolus were cleaned meticulously through scaling and irrigation with physiological serum to eliminate any root or bone debris. The flaps were sutured with 3.0 Vycril. After the procedures, the patients received post-surgical instructions verbally and in writing and amoxicillin capsules of 500 mg were every eigth hours for seven days as well as ibuprofen in 400 mg tablets every five hours for six days.

  At the end of data collection these were organized and transferred to Microsoft Excel 2010 for Windows, then analyzed and interpreted in the statistical program SPSS v 22 IBM. To verify if the data adjusted to a normal distribution these were subjected to the Kolmogorov-Smirnov test.

  All results rejected the hypothesis of normality, only width0 (sig. = 2.00) and height1 (sig. = 0.072) did not reject the hypothesis of normality. In consequence the data was analyzed with the test of Friedman for k related samples and the Wilcoxon test for two related samples. Both tests had a level of significance of 0.01.

RESULTS

When the data obtained was submitted to Friedman test for related samples, it resulted that there was a statistically significant difference in the three assessed parameters (height, thickness and width) at the three times (T0, T1, T2) in the following manner: height p = 0.0268E-15, thickness p = 2.0617E-11 and width p = 0.001 *(Table I)*. There was quite a difference to make comparisons.

When analyzing measurement times two by two (T0 to T1, T0 to T2 and T1 to T2), through the Wilcoxon test for two related tests, the following data were obtained: there is statistical significance for height and thickness between T0 and T1 (p = 0.000) but not for width (p = 0.0582); there is no statistical significance in height between T0 and T2 (p = 0.397); regarding height between T1 and T2 there was a statistical significance (p = 1.3441E-9), which suggests that the alveolar bone recovered the initial height six months after the extraction of the impacted lower third molars. In thickness there was no statistical significance between T0 and

Table I. Variations in bone height, thickness and width after third molar extractions.

	T0		T1		T2		
	Mean	SD	Mean	SD	Mean	SD	p ¥ value
Height [mm]	3.44	1.39	3.96	1.36	3.83	4.87	$0.0268E^{-15}$*
Thickness [mm]	2.85	1.81	2.57	2.13	3.02	2.07	$2.0617E^{-11}$*
Width [mm]	15.58	1.24	14.77	3.49	14.23	4.08	0.001*

¥*: Friedman's Two-w*ay variance analysis-related samples.

T2 (p = 0.036), but there was between T1 and T2 (p = 1.8686E-9), which suggests that there was a recovery of the thickness of the alveolar bone. When performing the same analysis with width, a statistical significance was obtained between T0 and T2 (p = 0.000097) and between T1 and T2 (p = 0.000020), so it can be said that there was a decrease in alveolar bone width six months after the extractions of the third molars *(Table II)*.

By grouping and analyzing the data considering the jaws, through an analysis of Friedman, in the maxilla a statistically significant difference was obtained for height (p = 2.301), thickness (p = 9.079) and width (p = 0.0001), which indicates that there was great variation when comparing width, height and thickness of the alveolar bone in the maxilla at the three times (T0, T1 and T2) *(Table III)*. When applying the Wilcoxon test for related samples in the maxilla it turned out that for height and thickness between T0 and T1, there was statistical significance (p = 0.000) but not for width (p = 0.06); between height of T0 and T2 there was no statistical significance (p = 0.791), but there was in the comparison of T1 and T2 (p = 0.001), which confirms that there was a recovery in the alveolar bone height 6 months after the extraction of the third molars had been performed. When the data for thickness was submitted to the Wilcoxon test there was no statistical significance between T0 and T2 (p = 0.613), but there was difference between T1 and T2 (p = 0.001) which means that six months after the extractions of the third molars were made, there was a recovery in the alveolar bone thickness distal to the second upper molar. In the analysis for width with the Wilcoxon test there was a statistically significant difference when comparing T0 to T2 (p = 0.000019) and T1 to T2 (p = 0.001) *(Table IV)*, which indicates that opposite to the other variables there was no recovery in bone width and on the contrary there was evidence of a decline in bone width.

In the case of the mandible, there was statistical significance when applying the Friedman test for height (p = 0.000) and thickness (p = 0.000006) in T0, T1 and T2, that is to say that there was great variation of the data at the three times in height and width but not so in the measurement of width (p = 0.817) *(Table V)*. Using the Wilcoxon test to compare the height measurements between T0 and T1 a statistical significance for height (p = 0.000) and thickness (p = 0.033) was obtained but not for width (p = 0.456). Between T0 and T2 (p = 0.347) there was no statistically significant difference, but there was when comparing T1 to T2 (p = 0.000), which indicates that the mandible maintained the same trend of recovery in alveolar bone height six months after the third molar extractions. Applying the same test for comparison with the measurements of thickness there was a statistically significant difference between T0 con T2 (p = 0.017) and T1 to T2 (p = 0.0001), which indicates that contrary to what occurred with the maxilla there was a loss of bone thickness immediately and six months after the third molar extractions. In regard to the measurements of width no statistically significant difference was found between T1 to T2 (p = 0.183) and T0 to T2 (p = 0.153) *(Table VI)* thus suggesting that there was no variation in bone width immediately or six months after having performed the third molar extractions.

Table II. Contrast by couples.

	T0-T1	T0-T2	T1-T2
Height [mm]	0.000	0.397	$1.3441E^{-9}$
Thickness [mm]	0.000	0.036	$1.8686E^{-9}$
Width [mm]	0.0582	0.000	0.0000

Wilcoxon test.

Table III. Results in the maxilla.

(mm)	Valor de p*
Height	2.301
Thickness	9.079
Width	0.0001

Friedman's analysis.

Table IV. Contrast by couples.

	Maxilla		
(mm)	T0-T1	T0-T2	T1-T2
Height	0.000	0.791	0.001
Thickness	0.000	0.613	0.001
Width	0.06	0.000019	0.001

Wilcoxon test.

Table V. Results mandible.

(mm)	Valor de p*
Height	0.000
Thickness	0.000006
Width	0.817

Friedman's analysis.

DISCUSSION

In a study performed in 80 patients treated with distalization of the upper canines, the amount of bone created and the stability of the bone mass in time (beginning of orthodontic treatment T1, at the end of the treatment T2, two years after the treatment T3A and five years after treatment T3B) was assessed. The alveolus buccal width was measured at the level of the bone crest and 5 mm apical from the alveolar crest. During treatment, T1 to T2, the alveolar crest width was reduced by 4 per cent, and the height, by 0.26 mm; during the retention periods (T2-T3A, T2-T3B), the reduction of the alveolar ridge was 2 per cent on average, with individual variations, and the height was reduced by an average of 0.38.[11] When comparing the methodology and the results of the abovementioned study with the present study there are similarities that allows us to analyze bone behavior during the distalization and even compare cases with and without extraction after having removed the third molars.

In both studies bone stability was maintained at the end of treatment, both vertically and horizontally, with fluctuations during the different stages. However, numerically that stability is best measured in the present study since a recovery in two of the variables was perceived and in the other, there is a slight decrease; while in the mentioned study, the thickness measurements lower in percentiles but remain stable. These arithmetic differences can relate to the fact that in the case of immediate post-extraction distalization, the recovery and bone formation was benefited by the different molecules and proteins involved in the healing process of the alveolus, which would justify the slight increase of measurements in this project.

Additionally the imaging instrument used in this project provides more precision in comparison to the method that was used in the study by Nováčková[11] for the measurement of the variables. Although it must be taken into consideration the differences in the reference points for measurements and shape, in Nováčková's assessment, the measurements were made in plaster models; whereas in this study the measurements were obtained from images in third dimension which allowed in addition, to measure bone thickness which in this case recovered at the end of the measurement. This may be interpreted as a post-extraction benefit of immediate distalization.

Table VI. Contrast by couples.

	Mandible		
(mm)	T0-T1	T0-T2	T1-T2
Height	0.000	0.347	0.0001
Thickness	0.033	0.017	0.0001
Width	0.456	0.183	0.153

Wilcoxon test.

Some studies focus on the bone response to orthodontic treatment. Verna et al.,[12] studied the bone histomorphmetric response during dental movements associated with orthodontic treatments in mice. They found that the fraction of alveolar bone (bone volume/ total volume) decreased significantly around the displaced teeth.

In the present study, stability and recovery of bone dimensions were obtained, in contrast with the abovementioned previous reports. This may be explained by the fact that the evaluation was carried out at different times of the post-extraction treatment, providing sufficient time for tissue remineralization; such as it happened in the investigation by Patil et al.,[13] where changes in bone density of the crest and subcrestal regions of the interproximal bone of posterior teeth during orthodontic treatment were evaluated using digital radiography of quantitative subtraction. In their study, they found that 23 out of 28 evaluated regions (82.14%) showed an increase in bone density.

A systematic review submitted by Bollen in 2008[14] identified the absence of strong evidence describing positive effects of orthodontic movements in periodontal health. Their findings suggest that orthodontic therapy results in small effects to the detriment of the periodontium.

Weak evidence of a randomized study and 11 non-randomized studies show that orthodontic treatment is associated with 0.03 mm of gingival recession, 0.13 mm of alveolar bone loss and 0.23 mm increase in the periodontal pocket depth when compared with patients that did not undergo treatment. However, orthodontic movement is a factor for stimulating bone apposition. It has also been demonstrated the recovery of bone health after orthodontic movements even when the defects involve periodontal structures.

Many non-invasive methods can be used in the measurement of alveolar bone density, including microradiographs of digital image,[15] X-ray absorption of dual energy[16] and ultrasound.[17] However, all these tools have inherent limitations, such as the absence of three-dimensional information and that they only allow a qualitative assessment.

In this report when comparing the results of the measurements of both jaws, a better recovery was observed in the maxilla in relation to the mandible and although it is a slight difference, it is significant. These findings contrast with those obtained in a study that used histomorphometric methods to assess post-extraction bone recovery, where it was concluded that the mandible recovered two times faster than the maxilla.[18] Amler explains that this situation is due to the fact that the mandible is subjected to strong mechanical forces and consequently has a greater capacity for healing than the maxilla.[19] The dynamism imposed by muscular strength in the bone causes complex patterns of stress and tension in the mandible, such as bending, sagittal and transversal deformation and twist.[20]

In contrast, the maxilla and pre-maxillary bones are exposed mainly to forces generated by the occlusal contact with the lower teeth.[21] However, in these studies an orthodontic force towards an extraction place was not included, which would explain the slight advantage of the maxilla over the mandible in this case, since there is an additional mechanical traction and rich vascularization that would serve as interveners and facilitators of the recovery of bone density.

CONCLUSIONS

With this study and even taking into consideration its limitations, it may be concluded that the bone structure after the removal of the third molars is maintained and it radiographically increases thanks to distalization orthodontic movements. This was demonstrable by cone beam measurements.

Bone height is the variable that benefited the most from orthodontic movement because although it decreased at the second measurement time (eight days), it increased at the third measurement time (six months) thus concluding that this is a prudent time to consider for the recovery of the bone after extractions as far as distalization movements are concerned.

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