PONTIFÍCIA UNIVERSIDADE CATÓLICA DE MINAS GERAIS
Programa de Pós-graduação em Odontologia

Aléxia Sampaio Teixeira

INFLUÊNCIA DO REBORDO ÓSSEO MAXILAR REMANESCENTE NA ESTABILIDADE VOLUMÉTRICA DE ENXERTOS UTILIZADOS NA ELEVAÇÃO DO SEIO MAXILAR

Belo Horizonte
2017

Aléxia Sampaio Teixeira

INFLUÊNCIA DO REBORDO ÓSSEO MAXILAR REMANESCENTE NA ESTABILIDADE VOLUMÉTRICA DE ENXERTOS UTILIZADOS NA ELEVAÇÃO DO SEIO MAXILAR

Dissertação apresentada ao Programa de Pós-graduação em Odontologia da Pontifícia Universidade Católica de Minas Gerais, como requisito parcial para obtenção do titulo em Mestre em Odontologia, Área de Concentração: Implantodontia.
Linha de Pesquisa: Propriedades biomecânicas, físico-químicas e biocompatibilidade dos biomateriais e materiais odontológicos.

Orientador: Prof. Dr. Rodrigo Villamarim Soares

Belo Horizonte
2017

FICHA CATALOGRÁFICA
Elaborada pela Biblioteca da Pontifícia Universidade Católica de Minas Gerais

Teixeira, Aléxia Sampaio
T266i Influência do rebordo ósseo maxilar remanescente na estabilidade volumétrica de enxertos utilizados na elevação do seio maxilar / Aléxia Sampaio Teixeira. Belo Horizonte, 2017.
55 f. : il.

Orientador: Rodrigo Villamarim Soares
Dissertação (Mestrado) – Pontifícia Universidade Católica de Minas Gerais. Programa de Pós-Graduação em Odontologia

1. Implantes dentários. 2. Seio do maxilar. 3. Materiais biomédicos. 4. Tomografia computadorizada. 5. Transplante ósseo. 6. Aumento do Rebordo Alveolar. I. Soares, Rodrigo Villamarim. II. Pontifícia Universidade Católica de Minas Gerais. Programa de Pós-Graduação em Odontologia. III. Título.

CDU: 616.314-089.843

Aléxia Sampaio Teixeira

INFLUÊNCIA DO REBORDO ÓSSEO MAXILAR REMANESCENTE NA ESTABILIDADE VOLUMÉTRICA DE ENXERTOS UTILIZADOS NA ELEVAÇÃO DO SEIO MAXILAR

Dissertação apresentada ao Programa de Pós-graduação em Odontologia da Pontifícia Universidade Católica de Minas Gerais, como requisito parcial para obtenção do título de Mestre em Odontologia. Área de Concentração: Implantodontia.

COMPOSIÇÃO DA BANCA EXAMINADORA:

1- Prof. Dr. Leandro Napier de Souza – UFMG
2- Prof. Dr. Élton Gonçalves Zenóbio – PUC Minas
3- Prof. Dr. Rodrigo Villamarim Soares – PUC Minas

DATA DA APRESENTAÇÃO E DEFESA: 11 de julho de 2017

A dissertação, nesta identificada, foi aprovada pela Banca Examinadora

Prof. Dr. Rodrigo Villamarim Soares
Coordenador do Programa de Pós-graduação em Odontologia

AGRADECIMENTOS

Após dois anos de muito esforço e dedicação gostaria de agradecer a algumas pessoas que foram essenciais em minha jornada.

Primeiro agradeço a Deus por colocar pessoas especiais na minha vida e me dar força e fé para seguir meu caminho.

Agradeço aos meus pais, Cláudio e Patrícia, por apoiarem minhas decisões e sempre acreditarem na minha capacidade. Obrigada pelo amor incondicional, vocês me fazem querer buscar o melhor em mim.

À minha irmã Alessandra pelo o apoio e carinho.

À minha família, especialmente minhas avós Hilda e Selma, sou grata pelo amor e admiração que sempre tive de vocês. Aos meus avôs Neider e João e Tio Neidinho obrigada pelo carinho e cuidado que tiveram comigo durante o tempo que estivemos juntos.

Ao Ely obrigada pelo companheirismo e por sempre me motivar, fazendo acreditar que posso mais do que imagino.

Ao meu orientador Rodrigo Villamarim Soarem pela paciência, apoio e instruções acadêmicas essenciais para a construção deste trabalho.

Ao Elton Gonçalves Zenóbio, obrigada por suas valiosas orientações e contribuições para realização desse projeto.

Ao Martinho Campolina pelo grande auxílio na análise estatística.

Ao Bruno Vidigal por sua contribuição na realização das medidas tomográficas.

À Silvania por realizar a formatação desta dissertação.

Ao corpo docente do Mestrado agradeço pelos ensinamentos teóricos e práticos transmitidos sempre com grande dedicação.

Aos meus colegas de Mestrado pelo companheirismo e pelos momentos divididos nestes dois anos.

À equipe de funcionários da PUC Minas que facilitaram nossa trajetória e se dedicaram a nos ajudar com toda disponibilidade, simpatia e gentileza.

Aos pacientes, agradeço por toda confiança que me ajudou no desenvolvimento profissional.

Acredito que ninguém vence sozinho, por isso obrigada a todos.

“Aos outros, dou o direito de ser como são. A mim, dou o dever de ser cada dia melhor.” (Chico Xavier).

RESUMO

O levantamento de seio maxilar, por meio do uso de enxertos de diferentes biomateriais é uma técnica previsível e de grande utilização na implantodontia. No entanto a influência de diferentes variáveis anatômicas nos enxertos para elevação do seio maxilar não está bem definida. O presente estudo avaliou a influência do rebordo ósseo maxilar residual na estabilidade volumétrica dos enxertos. Imagens tomográficas computadorizadas cone bean (CBTC) obtidas aos 15 dias (T1) e 180 dias (T2) após a elevação do seio maxilar com biomateriais Bio-Oss® Large (n = 8; Geistlich), Bio-Oss® Small (n = 8; Geistlich), Cerasorb (n = 7; Curasan Ag) e Osteogen (n = 7; Intra-Lock System) foram utilizadas. Sessenta imagens em formato DICOM (Digital Imaging and Communication in Medicine) foram analisadas pelo software OsiriX Imaging® (Pixmeo SARL, Genebra, Suiça) para mensurações lineares e volumétricas. Os dados foram submetidos ao teste de normalidade D`Agostino. Os testes T pareado, Anova e a correlação de Pearson foram utilizados na avaliação do volume de enxerto em T1 e T2, assim como na relação deste com as variáveis altura e profundidade do rebordo remanescente nas regiões de pré-molares e molares. Uma contração significativa de todos os biomateriais ($p < 0,05$), assim como uma maior contração ($p < 0,05$) do Cerasorb em relação ao Bio-Oss® Large e Bio-Oss® Small foi observada. O volume do rebordo mostrou correlação negativa com a contração do enxerto remanescente no grupo onde os biomateriais foram agrupados, e na análise individual com o Osteogen. As variáveis de altura e profundidade do rebordo na região de pré-molares e molares não se correlacionam com alterações volumétricas dos enxertos remanescentes.

Palavras-chave: Implantes dentários. Seio maxilar. Enxertos. Rebordo ósseo.

ABSTRACT

The maxillary sinus lift, through the use of grafts of different biomaterials, is a predictable and widely used technique in implantology. However, the influence of different anatomical variables on grafts for maxillary sinus elevation is not well defined. The present study evaluated the influence of the residual maxillary bone ridge on the volumetric stability of the grafts. Cone bean computed tomography (CBTC) images obtained at 15 days (T1) and 180 days (T2) after maxillary sinus elevation with biomaterials Bio-Oss® Large (n = 8; Geistlich), Bio-Oss® Small (n = 8, Geistlich), Cerasorb (n = 7; Curasan Ag), and Osteogen (n = 7; Intra-Lock System) were used. Sixty DICOM (Digital Imaging and Communication in Medicine) images were analyzed by OsiriX Imaging® software (Pixmeo SARL, Geneva, Switzerland) for linear and volumetric measurements. Data were submitted to the normal D'Adostino test. The paired T, ANOVA, and Pearson correlation tests were used to evaluate the graft volume in T1 and T2, as well as the relationship of this with the height and depth variables of the remaining ridge in the premolar and molar regions. A significant contraction of all biomaterials ($p <0.05$), as well as a greater contraction ($p <0.05$) of Cerasorb over Bio-Oss Large and Bio-Oss Small, was observed. The ridge volume showed negative correlation with the contraction of the remaining graft in the group where the biomaterials were grouped, and in the individual analysis with the Osteogen. The height and depth variables of the ridge in the region of premolars and molars do not correlate with volumetric changes of the remaining grafts.

Keywords: Dental implants. Maxillary sinus. Grafts. Bone ridge.

SUMÁRIO

1 INTRODUÇÃO 15

2 OBJETIVOS... 19
2.1 Objetivo geral 19
2.2 Objetivos específicos.. 19

3 ARTIGO CIENTÍFICO 21

4 CONSIDERAÇÕES FINAIS 51

REFERÊNCIAS.. 53

1 INTRODUÇÃO

O conhecimento das estruturas anatômicas que compõe o seio maxilar é essencial, uma vez que estas estruturas são de grande importância na prática odontológica devido à sua proximidade com os dentes, assim como por sua relevância no planejamento para a Implantodontia (ALBANI et al., 2003; WHAITES, 2003; WHITE; PHAROAH, 2007).

A perda dental na região posterior da maxila induz a expansão do seio maxilar, criando em determinadas situações uma união entre o assoalho do seio maxilar e a crista do rebordo alveolar remanescente (MISCH, 2008). Nesses casos enxertos devem ser utilizados para viabilização da reabilitação oral por meio do uso de implantes.

Substitutos ósseos têm sido utilizados como alternativa ao osso autógeno, permitindo um conforto pós-operatório maior aos pacientes. Diversos materiais xenógenos, alógenos ou aloplásticos têm sido empregados nos procedimentos com o objetivo de alcançar a mesma segurança de resultados que são obtidos com os enxertos autógenos de reconstrução do rebordo maxilar, tanto em altura, quanto em espessura, na elevação de assoalho de seio maxilar (BOYNE; JAMES, 1980; MOY; LUNDGREN; HOLMES, 1993; BROWAEYES; BOUVRY; BRUYN, 2007; PJETURSSON et al., 2008; BARONE et al., 2009, COSSO et al., 2014).

Apesar dos diferentes estudos realizados até a presente data, sobre a estabilidade volumétrica dos diferentes materiais de enxerto para o levantamento do assoalho do seio maxilar (WANSCHITZ et al., 2006; KIRMEIER et al., 2008; ARASAWA et al., 2012; KLIJN et al. 2012; KIM et al., 2013; SBORDONE et al., 2013; GUO et al., 2013; COSSO et al., 2014; UMANJEC-KORAC et al., 2014; GORLA et al., 2015; BERBERI et al., 2015; XAVIER et al., 2015); nenhum destes autores avaliaram a influência das estruturas anatômicas do seio maxilar na contração e regeneração dos diferentes materiais de enxertos utilizados neste procedimento. Diante do estado atual da literatura sobre este tema, deve-se considerar a hipótese de que fatores anatômicos do seio maxilar de forma isolada ou associada possam estar correlacionados com a reabsorção e reparação de diferentes tipos de materiais de enxertos no levantamento do seio maxilar.

A influência de diferentes fatores anatômicos como volume total do seio maxilar, rebordo residual maxilar, desvio de septo, osteomeatal e espessura da membrana sinusal, nos enxertos obtidos (volume- formação óssea-densidade óssea) por meio de Tomografia Computadorizada em diferentes períodos de estudos merecem atenção como alvo de estudos.

Estudo histológico e tomográfico de Kolerman, Tal e Moses (2008) assumiu a plausibilidade de que quanto maior o volume do seio maxilar maior a contração e tempo de neoformação óssea. No entanto, o estudo tomográfico de Favato et al. (2015) estabeleceu a relação da conformação tridimensional do seio maxilar quanto à regeneração óssea do enxerto posicionado entre estas paredes. Esse estudo demonstrou que não existem evidências suficientes de que o volume do seio maxilar influencie na contração de diferentes materiais utilizados em enxerto e sim o tipo e a característica do biomaterial.

De maneira similar, a comparação do volume de dois tipos de enxerto por meio de TCCB, duas semanas e seis meses após o procedimento de levantamento de seio, Kühl (2015) concluiu que a diminuição do volume do enxerto ocorreu de forma independente do tipo de biomaterial utilizado.

A avaliação das dimensões ósseas do rebordo maxilar remanescente é fundamental no planejamento para a colocação de implantes nesta região. Katsoulis (2012) avaliou 52 tomografias computadorizadas cone beam (TCCB), de pacientes com no mínimo um ano de endentulismo que receberam implantes. Foram feitas medidas digitais em nível da crista e região basal permitindo calcular a largura óssea relativa. Por meio de tais dados, foi concluído que a largura óssea na região posterior da maxila aumentou no nível da crista e região basal, e que a espessura do palato e a mucosa bucal estavam estáveis.

Em relação a altura do rebordo maxilar remanescente e sua influência no enxerto para elevação do seio maxilar pode-se identificar o estudo de Avila-Ortiz et al. (2012) que analisaram a influência da altura do osso maxilar residual nos resultados histomorfométricos para procedimentos de aumento de seio maxilar. Nenhuma correlação significativa entre altura do rebordo ósseo e proporção do volume ósseo formado foi encontrada. Os resultados sugerem que a altura do osso alveolar remanescente não parece influenciar a maturação e consolidação de um enxerto, no seio maxilar.

Portanto, embora o levantamento de seio maxilar, por meio do uso de enxertos, com utilização de diferentes biomateriais seja uma ferramenta muito importante na implantodontia, a investigação da relação entre o volume ósseo residual do rebordo maxilar e a contração do enxerto final obtido ainda não é conclusiva.

2 OBJETIVOS

2.1 Objetivo geral

Avaliar por meio de imagens tomográficas cone bean a relação entre as dimensões ósseas do rebordo maxilar remanescente com alterações dimensionais de diferentes tipos de enxertos.

2.2 Objetivos específicos

a) avaliar por meio de imagens tomográficas cone bean enxertos obtidos por meio de diferentes tipos de biomateriais a existência de variação dimensional no período de 180 dias pós-cirúrgico após elevação do seio maxilar;
b) avaliar por meio de imagens tomográficas cone bean possíveis correlações entre a altura, largura e volume do rebordo com a contração dos enxertos obtidos por meio de diferentes tipos de biomateriais após elevação do seio maxilar.

3 ARTIGO CIENTÍFICO

Influence of the remaining maxillary bone ridge on the volumetric stability of grafts used in maxillary sinus elevation

Artigo formatado de acordo com as normas de publicação do periódico **Clinical Oral Implants Research** (Qualis A1).

Endereço eletrônico:

http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)16000501/homepage/ForAuthors.htm

Influence of the remaining maxillary ridge on the volumetric stability of grafts used in maxillary sinus elevation

Authors' affiliations:

Aléxia Sampaio Teixeira

Elton Gonçalves Zenóbio

Bruno César Ladeira Vidigal

Martinho Campolina Rebello Horta

Rodrigo Villamarim Soares

Post-graduation Program in Dentistry of Pontifícia Universidade Católica de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil.

Key words: Dental implants. Maxillary sinus. Grafts. Maxillary bone ridge.

Corresponding author:

Rodrigo Villamarim Soares

Pontifícia Universidade Católica de Minas Gerais - Dentistry Department

Av. Dom José Gaspar 500 – Coração Eucarístico

Belo Horizonte - MG - Brazil - CEP: 30535-901

Tel: (31) 33194414

E-mail: rodrigovsoares@gmail.com

Abstract

Objective: To evaluate cone bean computer tomography (CBCT) images, the relationship between the dimensions of the remaining maxillary ridge, and the dimensional changes of the grafts obtained through different types of biomaterials after maxillary sinus lift.

Material and methods: The volume variation of the grafts and the volume of the remaining maxillary ridge were evaluated in 60 CBCT tomographic images obtained 15 days (T1) and 180 days (T2) postoperatively using Osirix Imaging 6.5 software (Pixmeo Geneva, Switzerland). The 30 maxillary sinuses were filled with the following biomaterials: Bio-Oss® Large (n = 8), Bio-Oss® Small (n = 8), Cerasorb (n = 7), and Osteogen (n = 7) grafts. The D`Agostino & Pearson test demonstrated the normal distribution of the data obtained. The paired T-test was used to evaluate graft volume. The ANOVA tested a criterion, followed by Dunn's post hoc test that evaluated the remaining grafts between the biomaterials. The Pearson correlation test evaluated the possible relationship between the remaining graft and the height, depth, and volume variables of the ridge in the premolar and molar regions.

Results: A significant contraction of all biomaterials ($p < 0.05$), as well as a greater contraction ($p < 0.05$) of Cerasorb over Bio-Oss Large and Bio-Oss Small, was observed. The grafts obtained with the Osteogen biomaterial presented negative correlation (-0.78; $p < 0.05$) with the ridge volume in relation to the other biomaterials. The comparison between groups of major and minor remaining grafts with the height and depth variables in the region of premolars and molars and ridge volume did not reveal significant associations ($p > 0.05$).

Conclusion: All grafts presented significant volumetric contraction after 180 days. The height and depth variables of the ridge in the region of premolars and molars do not correlate with volumetric changes of the remaining grafts.

Introduction

Several xenogenic, allogeneic, or alloplastic materials have been used in procedures with the objective of achieving the same safe results obtained with autogenous grafts of reconstruction of the maxillary ridge, both in height and thickness, in the elevation of the maxillary sinus floor (Boyne & James 1980; Moy et al. 1993; Browaeyes et al. 2007; Pjetursson et al. 2008; Barone et al. 2009; Cosso et al. 2014).

Studies using cone bean tomography (CBTB) with different graft types have concluded that observed differences between the data indicate that the volumetric analysis performed using these images can provide highly accurate data (Wanschitz et al. 2006; Kirmeier et al. 2008; Sbordone et al. 2009; Arasawa et al. 2012; Guo et al. 2013; Kim et al. 2013; Umanjec-Korac et al. 2014; Cosso et al. 2014; Gorla et al. 2015; Berberi et al. 2015).

Although several studies have evaluated the volumetric stability of different graft materials for the removal of the maxillary sinus floor, the results of the present study are similar to those reported in the literature (Wanschitz et al. 2006; Kirmeier et al. 2008; Arasawa et al. 2012; Klijn 2012; Kim et al. 2013; Sbordone et al. 2013; Guo et al. 2013; Cosso et al. 2014; Umanjec-Korac et al. 2014; Gorla et al. 2015; Berberi et al. 2015; Xavier et al. 2015), none of these studies evaluated the influence of the anatomical structures of the maxillary sinus and the bony ridge in contraction and of the different biomaterials of grafts used in this procedure.

The histological and tomographic study of Kolerman et al. (2008) described the plausibility that the greater the volume of the maxillary sinus, the greater the contraction and the time of bone neoformation. However, a tomographic study by Favato et al. (2015) established the relation of the three-dimensional conformation of the maxillary sinus to the bone regeneration of the graft positioned between these walls. This study demonstrated that there is insufficient evidence that maxillary sinus volume influences the contraction of different graft materials, but rather the type and characteristics of the biomaterial. In contrast, comparing the volume of two types of graft by CBTB, two weeks and six months after the breast lift procedure, concluded that the reduction of graft volume occurred independently of the type of biomaterial used (Kühl 2015).

The evaluation of the bone dimensions of the remaining maxillary ridge is fundamental in planning for the placement of implants in this region. Katsoulis (2012) evaluated 52 cone beam CT scans (TCCB) from patients with at least one year of endentulism receiving implants. Digital measurements were made at the crest and basal level, allowing the calculation of relative bone width. By means of such data, it was concluded that the bone width in the posterior region of the maxilla increased at the crest and basal level, and that the thickness of the palate and buccal mucosa were stable.

Regarding the height of the remaining maxillary ridge and its influence on the graft for maxillary sinus elevation, Avila-Ortiz et al. (2012) study analyzed the influence of residual maxillary bone height on histomorphometric results for maxillary sinus augmentation procedures. No significant correlation between bone ridge height and proportion of bone volume formed was found. The results suggest that the height of the remaining alveolar bone does not appear to influence the maturation and consolidation of a graft in the maxillary sinus.

In view of the above, we investigated the influence of different anatomical factors, such as total maxillary sinus volume, maxillary residual ridge, septal deviation, and osteomeatal and sinus membrane thickness, in the grafts obtained (bone volume-bone formation) during different periods of time.

Material and methods

Ethical aspects and sample procurement

The procedures carried out in this study were approved by the Ethics and Research Committee of the Pontifical Catholic University of Minas Gerais, number CAAE: 02663212.90000.5137. The study has a retrospective observational design. TCCB images of patients who underwent maxillary sinus lift were used. The sample consisted of 60 TCCB images of 30 maxillary sinuses, in which four types of biomaterials were used: Bio-Oss® Large (n = 8; Geistlich), Bio-Oss® Small (n = 8; Geistlich), Cerasorb = 7; Curasan Ag), and Osteogen (n = 7; Intra-Lock System).

Tomographic evaluation

The TCCB was performed 15 days (T1) and 180 days (T2) after the maxillary sinus procedure. Some samples were removed due to the cut of the collar in the computed tomography images. The selected images were saved in DICOM (Digital Imaging and Communication in Medicine) format and imported into OsiriX Imaging® software (Pixmeo SARL, Geneva, Switzerland) for T1 and T2. CT scans were analyzed, and the limits of the alveolar ridge and bone graft were measured. The delimitations were performed separately by a calibrated radiologist using the Pencil tool in the Osirix Imaging® program. The border was delimited below the maxillary sinus floor and the volumetric results were obtained by the Computed Volume tool.

The volume of the graft was also evaluated by the Pencil tool of the OsiriX Imaging® program, delimiting the entire extent of the bone graft. The volumetric result was obtained through the software after delimiting the regions using the Computed Volume tool.

The linear measurement was performed by the linear tool of the same program. This occurred from the lowest point of the alveolar ridge to the most superior point of the border of the alveolar ridge, this being the basal wall of the maxillary sinus. The pre-molar and molar regions were selected for measurement, since these regions are usually used for implant placement in the posterior region. In each region, three measurements were made vertically and three horizontally in the coronal and sagittal sections and three horizontal measurements were made to standardize the measurements.

The reference points were from the closure of the incisive foramen in the axial image and, using the Dental 3D software plugin feature, a point of the premolar and molar region was established. The corresponding sections of the other planes were shown in the program (Figures 1 to 8).

The analyzed data contains the remaining volume of the bone graft, volume T2 being divided by T1, the volume of the ridge, and the linear height and depth data of the ridge in the region of premolars and molars in the examination tomography.

Statistical analysis

The data were initially submitted to the D'Agostino & Pearson normality test, which showed a normal distribution. The paired t-test was used to assess the existence of differences between T1 and T2 graft volume. This analysis was performed separately for each biomaterial and for the pooled biomaterials. The

ANOVA one-criterion test, followed by Dunn's post hoc test, was used to assess the existence of differences in the remaining graft between the biomaterials. The Pearson correlation test was used to evaluate the existence of a correlation between the remaining graft and the following variables: ridge height (pre-molar); depth of the ridge (pre-molar); ridge height (molar); depth of the collar (molar); volume of the collar. This analysis was performed separately for each biomaterial and for the pooled biomaterials. Fischer's exact test was used to evaluate the existence of differences between groups with the lowest remaining graft and the largest remaining graft, considering the following variables: ridge height (pre-molar); depth of the ridge (pre-molar); ridge height (molar); depth of the collar (molar); volume of the collar. For this analysis, dichotomous variables were generated from a cutoff point made with the median values. The groups with the lowest remaining graft and the largest remaining graft were generated from a cutoff point made with the median values. This analysis was performed only for the pooled biomaterials. The level of significance was set at 5%. Analyses were performed using GraphPad Prism 6.05 software (GraphPad Software, San Diego, California, USA).

Results

Comparison of graft volume in T1 and T2 showed significant contraction ($p < 0.05$), both in the group containing the clustered biomaterials and in the specific groups (Table 1).

Regarding the graft, Bio-Oss® Large and Small presented no significant differences. Osteogen was similar to all biomaterials. However, the Cerasorb graft value remained significantly ($p < 0.05$) lower than Bio-Oss® Large and Small (Table 2).

The correlation between the remaining graft and the height of the ridge (pre-molar, molar), depth of the ridge (pre-molar, molar), and ridge volume revealed significant differences only in relation to the volume of the ridge. In the group containing the biomaterials ($p < 0.05$; -0.36), as well as in Osteogen ($p < 0.05$; - 0.78), the larger the volume of the collar, the greater the contraction observed (Table 3).

The analysis between groups with smaller and larger remaining grafts in relation to the variables - height of the ridge (pre-molar, molar), depth of the ridge (premolar, molar), and ridge volume - did not detect a significant relationship between these variables (Table 4).

Discussion

Although the maxillary sinus survey using grafts with different biomaterials is a very important tool in implantology, the investigation of the relationship between the residual bone volume of the maxillary ridge and the contraction of the final graft obtained is not yet conclusive. Therefore, the present study investigated the relationship of the residual maxillary bone ridge with the volumetric stability of the grafts obtained through different biomaterials.

Placement of implants in the posterior region of the maxilla for patients with poor bone availability became viable with the maxillary sinus lift procedure and the use of grafts (Sbordone et al. 2013). In the present study, the maxillary sinus grafts were obtained through the biomaterials, Bio-Oss® Large and Small-hydroxyapatite xenografts, alloplastic Osteogen hydroxyapatite synthetic, and Cerasorb calcium phosphate; these were evaluated by means of TCCB images, as described previously (Favato et al. 2015).

The behavior of the biomaterial is dependent on its physico-chemical characteristics and, as the main clinical effect, the resorption of this material and its sustainability capacity for bone formation can be evidenced. In this context the studies of Wu et al. (2016), Gorla et al. (2015) and Piattelli et al. (1999) are considered the gold standard of the autogenous graft through osteoconductive and osteoinductive properties, as well as the absence of immunogenic reaction. However, this approach determines the need for a surgical donor region, causing greater risk and postoperative discomfort. Also, as a disadvantage and in the context of the stability of the graft obtained, the autogenous graft may have contraction and reabsorption of up to 45% over time (Shanbhag et al. 2014; Sbordone et al. 2013; Schlegel et al. 2003). However, when associated with xenogenic hydroxyapatite, an improvement in the clinical behavior of the autogenous graft is observed (Cosso et al. 2014).

Evaluation of the biomaterials used showed that Bio-Oss® Large, Bio-Oss® Small, and Osteogen similarly contract. Considering the two particle sizes of Bio-Oss® in relation to volumetric stability, the results observed were similar to Chackartchi et al. (2011), who obtained the samples of refined surgical sites and CT scans of 10 patients, 6-9 months after surgery. After clinical, histological, and computed tomography evaluations, the authors concluded that there was no statistically significant difference between the groups. Therefore, in relation to volumetric stability, the choice of particle size is a clinical preference. A similar result was obtained by Jensen et al. (2015), who used both Bio-Oss® material particle sizes in sinus elevation in mini pigs evaluated 6 and 12 weeks after surgery. The small particle showed a histologically better marginal osteoconductivity, but this result did not affect the amount and velocity of the bone tissue formed. However, the study by Testori (2013), which, through a histomorphometric examination of specimens obtained from maxillary sinus grafts, showed a statistical difference in the amount of bone formed when the largest Bio-Oss® particle was used.

The largest volume contraction for the graft obtained by the Cerasorb® biomaterial over Bio-Oss® Large and Bio-Oss® Small is corroborated by the study by Favato (2015), as well as the results of Browaeys et al. (2007) in a systematic review. Other studies analyzed the amount of remaining ridge for immediate implant installation. In these, the influence of the measurements can be correlated with the graft formed (Zheng et al. 2011; Oliveira et al. 2012). However, in the present study the height and depth of the premolars and molars, as well as the ridge volume, did not significantly influence the contraction of the biomaterial. This result is similar to that reported by a previous study (Avila-Ortiz et al. 2012).

As described in other studies, there is still a deficiency to determine the better predictability of osseointegration for installed implants, as well as for aesthetics and the volumetric stability of grafts obtained with different biomaterials after maxillary sinus elevation (Kehr & Gosset 2000; Wanschitz et al. 2006; Kirmeier et al. 2008; Pjetursson et al. 2008; Klijn 2012; Arasawa et al. 2012; Kim et al. 2013; Sbordone et al. 2013; Vayron et al. 2013; Umanjec-Korac et al. 2014).

Regardless of the type of biomaterial used in the graft, dimensional changes that may influence the final graft volume over time are observed. This suggests the possible impairment of the stability of the implants installed in the grafts (Hurazeler et al. 1997; Haas et al. 1998; Browaeys et al. 2007).

In this context, similar studies that will evaluate the influence of different anatomical factors on the volumetric behavior and bone formation in the grafts obtained after maxillary sinus elevation should be conducted in order to increase the understanding of the biological phenomena involved, the biomaterials with the best performance, as well as indications of the use of implants in the rehabilitation of the population.

Referências

Arasawa, M., Oda, Y., Kobayashi, T., Uoshima, K., Nishiyama, H., Hoshina, H. & Saito, C. (2012) Evaluation of bone volume changes after sinus floor augmentation with autogenous bone grafts**.** *International Journal Oral Maxillofacial Surgery* **41:** 853-857.

Avila-Ortiz, G., Neiva, R., Galindo-Moreno, P., Rudek, I., Benavides, E. & Wang, H.L. (2012) Analysis of the influence of residual alveolar bone height on sinus augmentation outcomes. *Clinical Oral Implants Research* **23:** 1082-1088.

Barone, A., Varanini, P., Orlando, B., Tonelli, P. & Covani, U. (2009) Deep-frozen allogeneic onlay bone grafts for reconstruction of atrophic maxillary alveolar ridges: a preliminary study. *Journal of Oral and Maxillofacial Surgery* **67:** 1300-1306.

Berberi, A., Bouserhal, L., Nader, N., Assaf, R.B., Nassif, N.B., Bouserhal, J. & Salameh, Z. (2015) Evaluation of three-dimensional volumetric changes after sinus floor augmentation with mineralized cortical bone allograft. *Journal of Maxillofacial Oral Surgery* **14:** 624-629.

Boyne, P.J. & James, R.A. (1980) Grafting of the maxillary sinus floor with autogenous marrow and bone. *Journal of Oral Surgery* **38:** 613-616.

Browaeys, H., Bouvry, P. & Bruyn, H. (2007) A literature review on biomaterials in sinus augmentation procedures. *Clinical Implant Dentistry and Related Research* **9:**166-177.

Chackartchi, T., Iezzi, G., Goldstein, M., Klinger, A., Soskolne, A., Piattelli, A. & Shapira, L. (2011) Sinus floor augmentation using large (1-2 mm) or small (0.25-1 mm) bovine bone mineral particles: a prospective, intra-individual controlled clinical, micro-computerized tomography and histomorphometric study. *Clinical Oral Implants Research* **22:** 473-480.

Cosso, M.G., de Brito, R.B. Jr, Piattelli, A., Shibli, J.A. & Zenóbio, E.G. (2014) Volumetric dimensional change of autogenous bone and the mixture of hydroxyapatite and autogenous bone graft, in humans maxillary sinus augmentation. A multslice tomographic study. *Clinical Oral Implants Research* **25:** 1251-1256.

Favato, M.N., Vidigal, B.C., Cosso, M.G., Manzi, F.R., Shibli, J.A. & Zenóbio, E.G. (2015) Impact of human maxillary sinus volume on grafts dimensional changes used in maxillary sinus augmentation: a multislice tomographic study. *Clinical Oral Implants Research* **26:** 1450-1455.

Gorla, L.F., Spin-Neto, R., Boos, F.B., Pereira, R.S., Garcia-Junior, I.R. & Hochuli-Vieira, E. (2015) Use of autogenous bone and beta-tricalcium phosphate in maxillary sinus lifting: a prospective, randomized, volumetric computed tomography study. *International Journal of Oral and Maxillofacial Surgery* **44:** 1486-1491.

Guo, X.H., Jiang, Q., Ruan, H., Luo, Y. & Yu, Y.C. (2013) Evaluation of three-dimensional changes after sinus floor augmentation with DBBM. *Shanghai Kou Qiang Yi Xue* **22:** 448-452.

Hass, R., Donath, K., Födinger, M. & Watzek, G. (1998) Bovine hydroxyapatite for maxillary sinus grafting: comparative histomorphometric findings in sheep. *Clinical Oral Implants Research* **9:** 107-116.

Hürzeler, M.B., Quiñones, C.R., Kirsch, A., Gloker, C., Schüpbachs, P., Strub, J.R. & Caffesse, R.G. (1997) Maxillary sinus augmentation using different grafting materials and a dental implants in monkeys. *Clinical Oral Implants Research* **8:** 476-486.

Jensen, S.S., Aaboe, M., Janner, S.F., Saulacic, N., Bornstein, M.M., Bosshardt, D.D. & Buser, D. (2015) Influence of particle size of deproteinized bovine bone mineral on new bone formation and implant stability after simultaneous sinus floor elevation: a histomorphometric study in minipigs. *Clinical Implant Dentistry and Related Research* **17:** 274-285.

katsoulis, J. (2012) Relative bone width of the edentulous maxillary ridge. *Clinical Implant Dentistry and Related Research* 14: e213-223.

Kehr, P. & Gosset, F. (2000) Endobon R as a bone substitute in spine surgery preliminary study in 11 patients. *European Journal of Orthopaedic Surgery & Traumatology* **10:** 217-221.

Kim, E.S., Moon, S.Y., Kim, S.G., Park, H.C., Oh, J.S. (2013) Three-dimensional volumetric analysis after sinus grafts. *Implant Dentistry* **22:** 170-174.

Kirmeier, R., Payer, M., Wehrschuetz, M., Jakse, N., Platzer, S. & Lorenzoni, M. (2008) Evaluation of three-dimensional changes after sinus floor augmentation with different grafting materials. *Clinical Oral Implants Research* 19: 366-372.

Klijn, R.J. (2012) Predictive value of ridge dimensions on autologous bone graft resorption in staged maxillary sinus augmentation surgery using Cone-Beam CT. *Clinical Oral Implants Research* **23:** 409-415.

Kolerman, R., Tal, H. & Moses, O. (2008) Histomorphometric analysis of newly formed bone after maxillary sinus floor augmentation using ground cortical bone allograft and internal collagen membrane. *Journal of Periodontology* **79:** 2104-2111.

Kühl, S., Payer, M., Kirmeier, R., Wildburger, A., Acham, S. & Jakse, N. (2015) The influence of particulated autogenous bone on the early volume stability of maxillary sinus grafts with biphasic calcium phosphate: a randomized clinical trial. *Clinical Oral Implants Research* **17:** 173-178.

Moy, P.K., Lundgren, S. & Holmes, R.E. (1993) Maxillary sinus augmentation: histomorphometric analysis of graft materials for maxillary sinus floor augmentation. *Journal of Oral and Maxillofacial Surgery* **51:** 857-862.

Oliveira, R., Marc, E.H., Jean-Pierre, C., Lombardi, T. & Jean-Pierre, B. (2012) Re-habilitation of the edentulous posterior maxilla after sinus floor elevation using deproteinized bovine bone: a 9 year clinical study. *Implant Dentistry* **21:** 422-426.

Piattelli, M., Favero, G.A., Scarano, A., Orsini, G. & Piattelli, A. (1999) Bone reactions to anorganic bovine bone (Bio-Oss) used in sinus augmentation procedures: a histologic long-term report of 20 cases in humans. *The International Journal of Oral & Maxillofacial Implants* **14:** 835-840.

Pjetursson, B.E., Tan, W.C., Zwahlen, M. & Lang, N.P. (2008) A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. *Review Journal Clinical Periodontology* **35:** 216-240.

Sbordone, C., Toti, P., Guidetti, F., Califano, L., Bufo, P. & Sbordone, L. (2013) Volume changes of autogenous bone after sinus lifting and grafting procedures: a 6-year computerized tomographic follow-up. *Journal of Craniomaxillofacial Surgery* **41:** 235-241.

Sbordone, L., Toti, P., Menchini-Fabris, G.B., Sbordone, C., Piombino, P. & Guidetti, F. (2009) Volume changes of autogenous bone grafts after alveolar ridge augmentation of atrophic maxillae and mandibular. *International Journal of Oral and Maxillofacial Surgery* **38:** 1059-1065.

Schlegel, K.A., Fichtner, G., Schultze-Mosgau, S. & Wiltfang, J. (2003) Histologic findings in sinus augmentation with autogenous bone chips versus a bovine bone substitute. *The International Journal of Oral & Maxillofacial Implants* **18:** 53-58.

Shanbhag, S., Shanbhag, V. & Stavropoulos, A. (2014) Volume changes of maxillary sinus augmentations over time: a systematic review. *International Journal of Oral & Maxillofacial Implants* **20:** 881-892.

Testori, T. (2013) Effect of xenograft (ABBM) particle size on vital bone formation following maxillary sinus augmentation: a multicenter, randomized, controlled, clinical histomorphometric trial. *The International Journal of Periodontics & Restorative Dentistry* **33:** 467-475.

Umanjec-Korac, S., Wu, G., Hassan, B., Liu, Y. & Wismeijer, D. (2014) A retrospective analysis of the resorption rate of deproteinized bovine bone as maxillary sinus graft material on cone beam computed tomography. Clinical Oral Implants Research **25:** 781-785.

Vayron, R., Karasinski, P., Mathiue, V., Michel, A., Loriot, D., Richard, G., Lambert, G. & Haiot, G. (2013) Variation of the ultrasonic response of a dental implant embedded in tricalcium silicate-based cement under cyclic loading. *Journal of Biomechanics* **46:** 1162-1168.

Wanschitz, F., Figl, M., Wagner, A. & Rolf, E. (2006) Measurement of volume changes after sinus floor augmentation with a phycogenic hydroxyapatite. *The International Journal of Oral & Maxillofacial Implants* **21:** 433-438.

Wu, J., Li, B. & Lin, X. (2016) Histological outcomes of sinus augmentation for dental implants with calcium phosphate or deproteinized bovine bone: a systematic review and meta-analysis. *International Journal of Oral and Maxillofacial Surgery* **45:** 1471-1477.

Xavier, S.P., Silva, E.R., Kahn, A., Chaushu, L. & Chaushu, G. (2015) Maxillary sinus grafting with autograft versus fresh-frozen allograft: a split-mouth evaluation of bone volume dynamics. *The International Journal of Oral & Maxillofacial Implants* **30:**1137-1142.

Zheng, X., Teng, M., Zhou, F., Ye, J., Li, G. & Mo, A. (2016) Influence of maxillary sinus width on transcrestal sinus augmentation outcomes: radiographic evaluation based on cone beam CT. *Clinical Implant Dentistry and Related Research* **18:** 292-300.

Table 1. Comparison of graft volume

Biomaterial	T1		T2		Average of the differences	Value of *p*[1]
	Average	DP	Average	DP		
Grouped (n=30)	1,93	1,08	1,48	1,00	-0,45 mm³	<0,05
Bio-Oss® Large (n=8)	1,82	0,77	1,47	0,62	-0,35 mm³	<0,05
Bio-Oss® Small (n=8)	1,70	1,50	1,41	1,43	-0,29 mm³	<0,05
Cerasorb (n=7)	1,66	0,49	0,97	0,51	-0,69 mm³	<0,05
Osteogen (n=7)	2,57	1,21	2,09	1,02	-0,48 mm³	<0,05

1 p-value obtained by paired t-test: T1 vs. T2
SD = standard deviation
ns = non-significant (p> 0.05)

Table 2. Comparison of the remaining graft between biomaterials

Bio-Oss® Large (1)	Bio-Oss® Small (2)	Cerasorb (3)	Osteogen (4)
Average ± DP	**Average ± DP**	**Average ± DP**	**Average ± DP**
0,81 ± 0,09 [A]	0,80 ± 0,13 [A]	0,56 ± 0,17 [B]	0,76 ± 0,19 [A,B]

[A, B] Values followed by different letters represent statistically significant differences in the comparison between pairs. P value obtained by the ANOVA test a criterion, followed by Dunn's post hoc test for comparison between pairs.

Table 3. Correlation between remaining graft and variables of interest

Biomaterial		Remaining graft	
		Value of p^1	Correlation coefficient (r)
Grouped	Rim height (bicuspid)	n.s.	0.01
	Flange depth (bicuspid)	n.s	0.23
	Rim height (molar)	n.s.	-0.17
	Flange depth (molar)	n.s.	0.05
	Lip volume	< 0.05	-0.36
Bio-Oss® Large	Rim height (bicuspid)	n.s.	0.10
	Deep rim (bicuspid)	n.s	0.59
	Rim height (molar)	n.s.	-0.18
	Flange depth (molar)	n.s	0.29
	Lip volume	n.s.	-0.46
Bio-Oss® Small	Rim height (bicuspid)	n.s.	0.27
	Flange depth (bicuspid)	n.s.	0.13
	Rim height (molar)	n.s.	-0.12
	Flange depth (molar)	n.s.	-0.63
	Lip volume	n.s.	-0.14
Cerasorb	Rim height (bicuspid)	n.s.	-0.15
	Flange depth (bicuspid)	n.s.	0.14
	Rim height (molar)	n.s.	0.27
	Flange depth (molar)	n.s.	0.24
	Lip volume	n. s	-0.24
Osteogen	Rim height (bicuspid)	n.s.	-0.40
	Flange depth (bicuspid)	n.s.	-0.23
	Rim height (molar)	n.s.	-0.60
	Flange depth (molar)	n.s.	0.13
	Lip volume	< 0.05	-0.78

[1] *P* value obtained by the Pearson correlation test
n.s.-not significant ($p > 0.05$)

Table 4. Comparison between groups with smaller and larger remaining graft, considering variables of interest

	Lower edge height (bicuspid) 1.43 mm³	Greater height from the edge (bicuspid) 8.58 mm³	Value of *p*[1]
Minor remaining graft (0.38 mm³)	8	7	n.s.
Largest remaining graft (0.99 mm³)	7	8	
	Smallest depth of rim (bicuspid) 2.71 mm³	Greater depth the rim (bicuspid) 6.94 mm³	Value of *p*[1]
Minor remaining graft (0.38 mm³)	9	6	n.s.
Largest remaining graft (0.99 mm³)	6	9	
	Lower edge height (molar) 0.93 mm³	Greater height from the edge (molar) 7.45 mm³	Value of *p*[1]
Minor remaining graft (0.38 mm³)	7	8	n.s.
Largest remaining graft (0.99 mm³)	8	7	
	Smallest depth of rim (molar) 1.34 mm³	Greater depth the rim (molar) 7.12 mm³	Value of *p*[1]
Minor remaining graft (0.38 mm³)	8	7	n.s.
Largest remaining graft (0.99 mm³)	7	8	
	Lower volume of 0.2 mm³	Greater volume of 7.8 mm³	Value of *p*[1]
Minor remaining graft (0.38 mm³)	6	9	n.s.
Largest remaining graft (0.99 mm³)	9	6	

[1] Value of p obtained by Fischer's exact test
n.s.-not significant ($p > 0.05$)
Note: For this analysis groups were generated and variables from a cut were made with the median of the values.

Legend of figures

Fig. 1 - Axial cut region of premolars and molars.

Fig. 2 - Vertical coronal cut.

Fig. 3 - Horizontal coronal cut.

Fig. 4 - Coronal cut - vertical and horizontal.

Fig. 5 - Horizontal sagittal cut.

Fig. 6 - Horizontal and vertical sagittal section.

Fig. 7 - Ridge volume.

Fig. 8 - Measurement method - height and depth assessment.

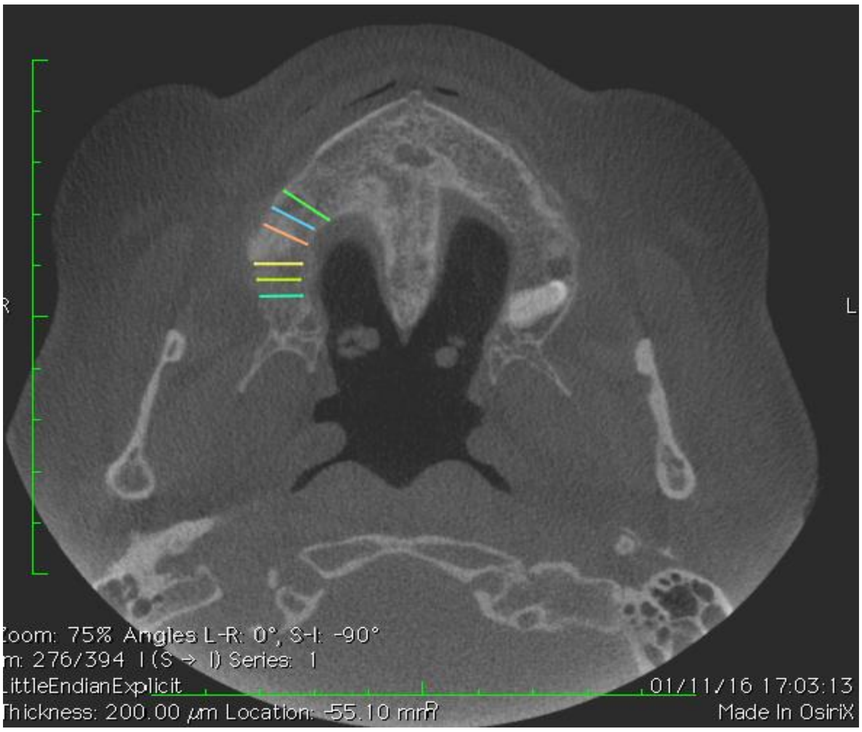
R
L
Zoom: 75% Angles L-R: 0°, S-I: -90°
m: 276/394 I (S → I) Series: 1
LittleEndianExplicit
01/11/16 17:03:13
Thickness: 200.00 μm Location: -55.10 mm
Made In OsiriX

Fig. 1.


oom: 146% Angles L-R: 0°, S-I: 0°
n: 384/800 (A → P) Series: 1
ittleEndianExplicit

Fig. 2.


WW: 5849
46% Angles L-R: 0°, S-I: 0°
300 (A -> P) Series: 1
anExplicit
: 200.00 µm Location: 76.60 mm

Fig. 3.

Fig. 4.

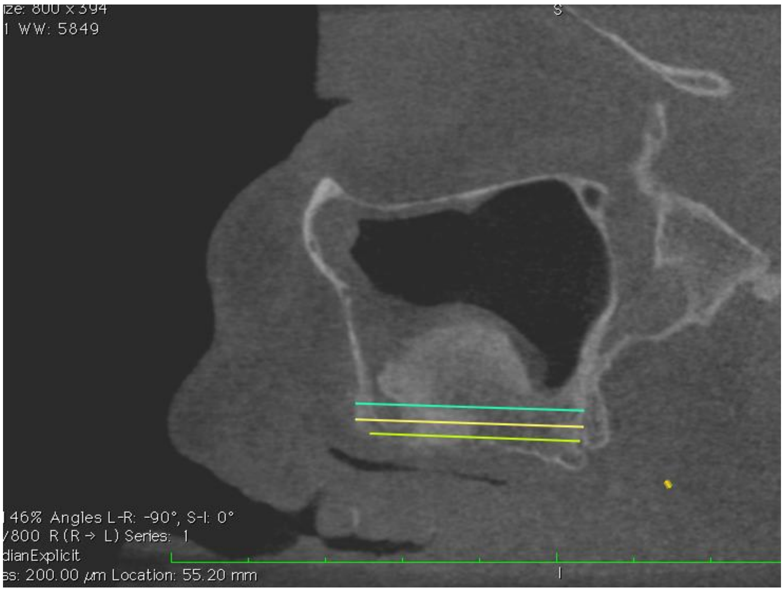
ize: 800 x 394
1 WW: 5849
S
146% Angles L-R: -90°, S-I: 0°
/800 R (R → L) Series: 1
dianExplicit
ss: 200.00 µm Location: 55.20 mm

Fig. 5.

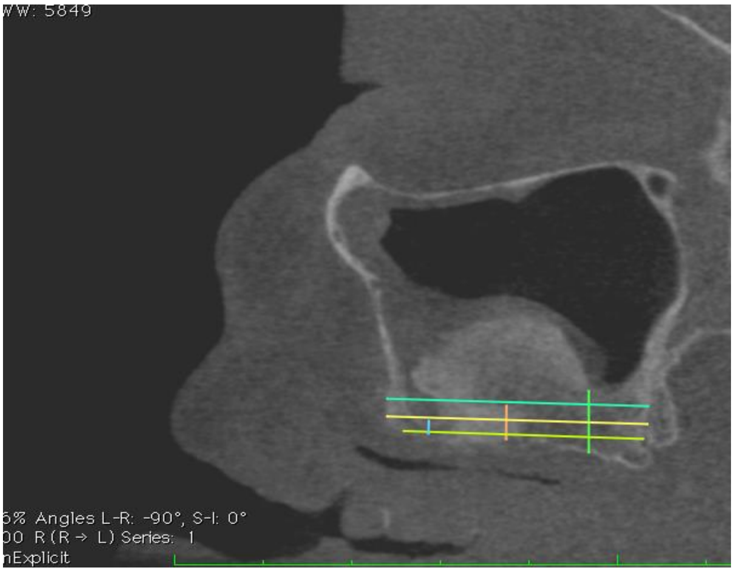

Fig. 6.

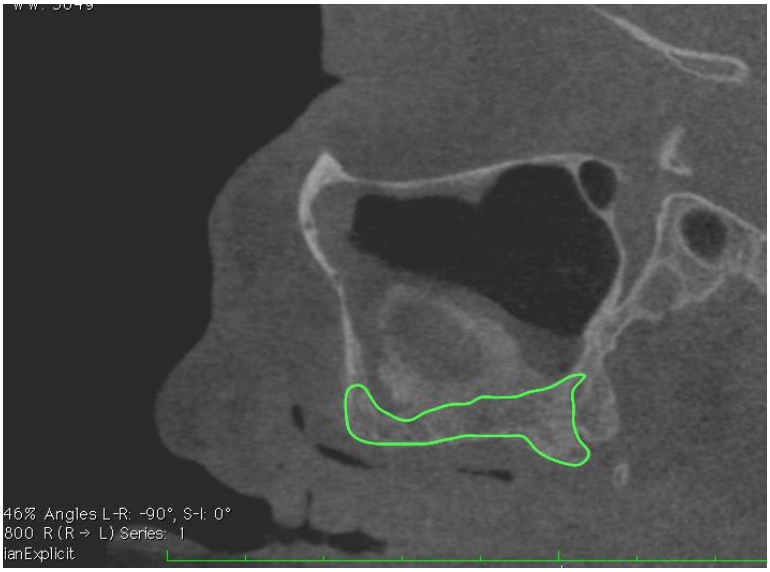

Fig. 7.

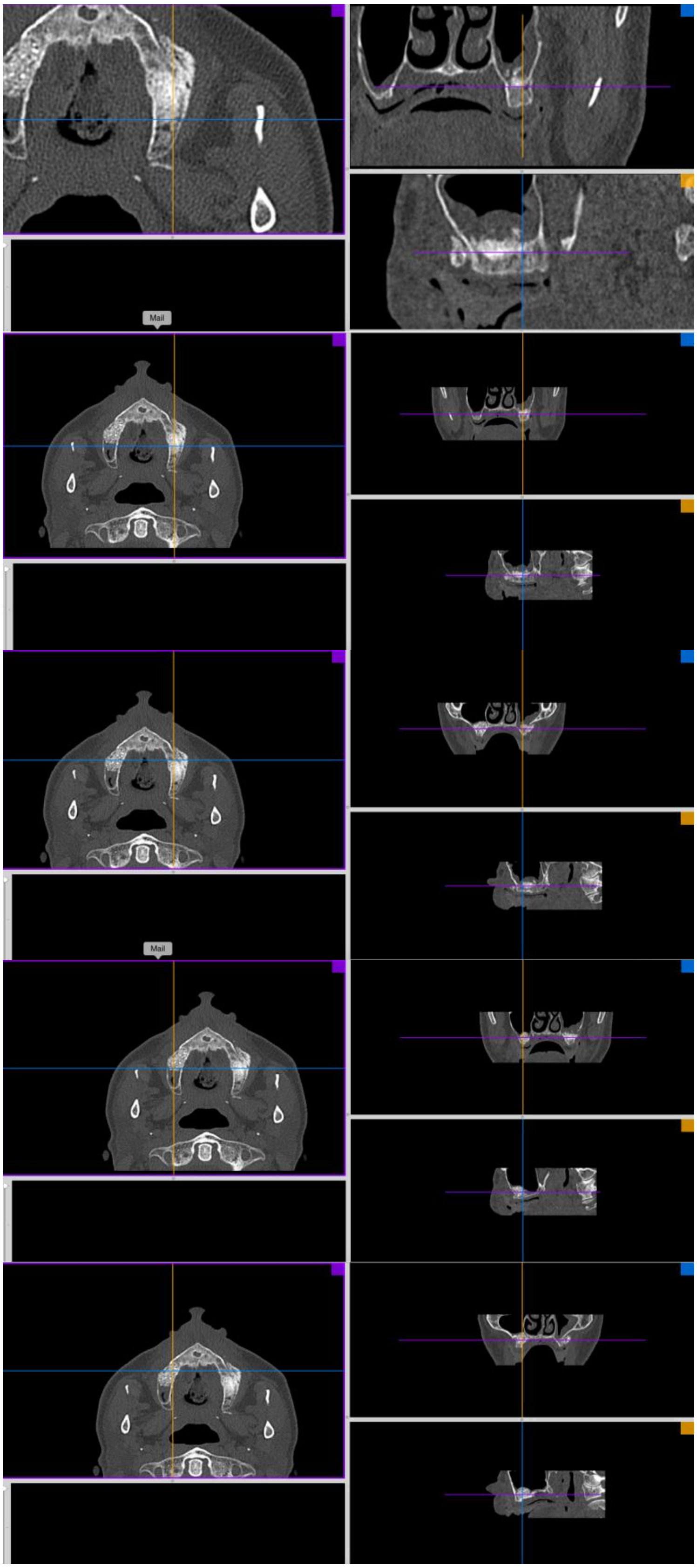

Fig. 8.

4 CONSIDERAÇÕES FINAIS

Os biomateriais usados nesse estudo apresentaram contração significativa. O Cerasorb apresentou um menor valor de enxerto remanescente em relação ao Bio-Oss®. Houve correlação negativa do enxerto remanescente com o volume do rebordo quando os biomateriais foram avaliados de maneira agrupada, assim como em relação ao Osteogen individualmente. O presente estudo indica que independente do biomaterial utilizado, a altura e profundidade do rebordo na região de pré-molares, assim como o volume do rebordo não apresentaram associações significativas.

REFERÊNCIAS

ALBANI, M.L. et al. Planejamento cirúrgico dos implantes dentários. **Revista Gaú-cha de Odontologia,** v.51, n.4, p. 260-264, 2003.

ARASAWA, M. et al. Evaluation of bone volume changes after sinus floor augmentation with autogenous bone grafts**. International Journal Oral Maxillofacial Surgery***,* v.41, n.7, p. 853-857, July 2012

AVILA-ORTIZ, G. et al. Analysis of the influence of residual alveolar bone height on sinus augmentation outcomes. **Clinical Oral Implants Research,** v.23, n.9, p. 1082-1088, Sept. 2012.

BARONE, A. et al. Deep-frozen allogeneic onlay bone grafts for reconstruction of atrophic maxillary alveolar ridges: a preliminary study. **Journal of Oral and Maxillofacial Surgery,** v.67, n.6, p. 1300-1306, June 2009.

BERBERI, A. et al. Evaluation of three-dimensional volumetric changes after sinus floor augmentation with mineralized cortical bone allograft. **Journal of Maxillofacial Oral Surgery,** v.14, n.3, p. 624-629, Sept. 2015.

BOYNE, P.J.; JAMES, R.A. Grafting of the maxillary sinus floor with autogenous marrow and bone. **Journal of Oral Surgery,** v.38, n.8, p. 613-616, Aug. 1980.

BROWAEYS, H.; BOUVRY, P.; BRUYN, H. A literature review on biomaterials in sinus augmentation procedures. **Clinical Implant Dentistry and Related Research,** v.9, n.3, p.166-177, Sept. 2007.

COSSO, M.G. et al. Volumetric dimensional change of autogenous bone and the mixture of hydroxyapatite and autogenous bone graft, in humans maxillary sinus augmentation. A multslice tomographic study. **Clinical Oral Implants Research,** v.25, n.11, p. 1251-1256, Nov. 2014.

FAVATO, M.N. et al. Impact of human maxillary sinus volume on grafts dimensional changes used in maxillary sinus augmentation: a multislice tomographic study. **Clinical Oral Implants Research,** v.26, n.12, p. 1450-1455, Dec. 2015.

GORLA, L.F.O. et al. Use of autogenous bone and beta-tricalcium phosphate in maxillary sinus lifting: a prospective, randomized, volumetric computed tomography study. **International Journal of Oral and Maxillofacial Surgery,** v.44, n.12, p. 1486-1491, Dec. 2015.

GUO, X.H. et al. Evaluation of three-dimensional changes after **sinus** floor augmentation with DBBM. **Shanghai Kou Qiang Yi Xue,** v.22, n.4, p. 448-452, Aug. 2013.

KATSOULIS, J. Relative bone width of the edentulous maxillary ridge. **Clinical Implant Dentistry and Related Research,** v.14, Suppl. 1, p. e213-223, May 2012.

KIM, E.S. et al. Three-dimensional volumetric analysis after sinus grafts. **Implant Dentistry,** v.22, n.2, p. 170-174, Apr. 2013.

KIRMEIER, R. et al. Evaluation of three-dimensional changes after sinus floor augmentation with different grafting materials. **Clinical Oral Implants Research,** v. 19, n. 4, p. 366-372, Apr. 2008.

KLIJN, R.J. Predictive value of ridge dimensions on autologous bone graft resorption in staged maxillary sinus augmentation surgery using Cone-Beam CT. **Clinical Oral Implants Research**, v.23, n.4, p. 409-415, Apr. 2012.

KOLERMAN, R.; TAL, H.; MOSES, O. Histomorphometric analysis of newly formed bone after maxillary sinus floor augmentation using ground cortical bone allograft and internal collagen membrane. **Journal of Periodontology,** v.79, n.11, p. 2104-2111, Nov. 2008.

KÜHL, S. et al. The influence of particulated autogenous bone on the early volume stability of maxillary sinus grafts with biphasic calcium phosphate: a randomized clinical trial. **Clinical Oral Implants Research**, v.17, n.1, p. 173-178, Feb. 2015.

MISCH, C.E. **Implantes dentários contemporâneos**. 2. ed. São Paulo: Santos, 2006.

MOY, P.K.; LUNDGREN, S.; HOLMES, R.E. Maxillary sinus augmentation: histomorphometric analysis of graft materials for maxillary sinus floor augmentation. **Journal of Oral and Maxillofacial Surgery,** v.51, n.8, p. 857-862, Aug. 1993.

PJETURSSON, B.E. et al. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. **Review Journal Clinical Periodontology**. v.35, Suppl. 8, p. 216-240, Sept. 2008.

SBORDONE, C. et al. Volume changes of autogenous bone after sinus lifting and grafting procedures: a 6-year computerized tomographic follow-up. **Journal of Craniomaxillofacial Surgery,** v.41, n.3, p. 235-241, Apr. 2013.

SBORDONE, L. et al. Volume changes of autogenous bone grafts after alveolar ridge augmentation of atrophic maxillae and mandibular. **International Journal of Oral and Maxillofacial Surgery,** v.38, n.10, p. 1059-1065, Oct. 2009.

UMANJEC-KORAC, S. et al. A retrospective analysis of the resorption rate of deproteinized bovine bone as maxillary sinus graft material on cone beam computed tomography. **Clinical Oral Implants Research**, v.25, n.7, p. 781-785, July 2014.

WANSCHITZ, F., et al. Measurement of volume changes after sinus floor augmentation with a phycogenic hydroxyapatite **The International Journal of Oral & Maxillofacial Implants,** v.21, n.3, p. 433-438, May/June 2006.

WHAITES, E. **Princípios de radiologia odontológica.** 3. ed. Porto Alegre: Artmed, 2003

WHITE, S.C.; PHAROAH, M.J. **Radiologia oral:** fundamentos e interpretação. 5. ed. Rio de Janeiro. Elsevier Editora, 2007.

XAVIER, S.P. et al. Maxillary sinus grafting with autograft versus fresh-frozen allograft: a split-mouth evaluation of bone volume dynamics. **The International Journal of Oral & Maxillofacial Implants,** v.30, n.5, p. 1137-1142, Sept./Oct. 2015.