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CENTRO DE CIÊNCIAS DA SAÚDE
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**Eduardo de Oliveira**

# QUANTIFICAÇÃO VOLUMÉTRICA DO REBORDO ALVEOLAR APÓS REANATOMIZAÇÃO DO ASSOALHO DO SEIO MAXILAR PARA INSTALAÇÃO DE IMPLANTES

Santa Maria, RS
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Dissertação apresentada ao Curso de Mestrado do Programa de Pós-Graduação em Ciências Odontológicas, Área de Concentração em Odontologia, ênfase em Radiologia, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do título de **Mestre em Ciências Odontológicas**.

ORIENTADORA: Profa. Dra. **Gabriela Salatino Liedke**

SANTA MARIA, RS
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**Aprovado em 09 de dezembro de 2021**

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## RESUMO

### QUANTIFICAÇÃO VOLUMÉTRICA DO REBORDO ALVEOLAR APÓS REANATOMIZAÇÃO DO ASSOALHO DO SEIO MAXILAR PARA INSTALAÇÃO DE IMPLANTES

AUTOR: Eduardo de Oliveira
ORIENTADORA: Gabriela Salatino Liedke

**Introdução:** A ausência dos dentes superiores posteriores leva à reabsorção óssea e pneumatização do seio maxilar, muitas vezes impedindo a inserção imediata do implante e levando à necessidade da realização de enxerto para levantamento do seio maxilar (LSM). **Objetivo:** Avaliar, em imagens de tomografia computadorizada de feixe cônico (TCFC), as alterações volumétricas no rebordo alveolar e seio maxilar após cirurgia de LSM, enxerto com substituto ósseo bovino e instalação de implantes dentários. **Materiais e métodos:** Foram avaliados o volume ósseo e sinusal de 16 seios maxilares de 12 pacientes submetidos ao LSM, enxerto ósseo e instalação de implantes. Exames de TCFC foram realizados em três momentos: avaliação do leito ósseo remanescente (T0), avaliação do enxerto após LSM para planejamento cirúrgico do implante (T1) e avaliação após cicatrização dos implantes (T2). As imagens em formato DICOM foram avaliadas por dois examinadores calibrados (ICC > 0,9) no software ITK-SNAP. O volume medido em cada tempo foi comparado utilizando o teste ANOVA. Variáveis clínicas e demográficas foram coletadas e a porcentagem de ganho e de reabsorção ósseas foram comparadas utilizando o teste t. O nível de significância considerado foi $P < 0,05$. **Resultados:** O rebordo ósseo apresentou aumento significativo após LSM (T1), com reabsorção óssea também significativa (T2); o volume sinusal apresentou redução significativa após LSM (T1) e manutenção deste volume ao longo do tempo (T2). Locais com variação volumétrica em T1 superior a 200% apresentaram menor reabsorção longitudinal ($p=0,036$), sem associação com variáveis clínicas ou demográficas ($p > 0,05$). **Conclusão:** O presente estudo encontrou aumento médio de 200% do rebordo ósseo após LSM e reabsorção média de 11% ao longo de quatro anos, após a instalação dos implantes, concentrada na região cervical dos implantes. O ganho ósseo e a reabsorção do volume enxertado não tiveram associação com variáveis clínicas ou demográficas dos pacientes.



**Palavras-chave:** Enxerto ósseo. Levantamento do Assoalho do Seio Maxilar. Implante Dentário. Tomografia Computadorizada de Feixe Cônico.

## ABSTRACT

### VOLUMETRIC QUANTIFICATION OF THE ALVEOLAR RIDGE AFTER REANATOMIZATION OF THE MAXILLARY SINUS FLOOR FOR IMPLANT INSTALLATION

AUTHOR: Eduardo de Oliveira
ADVISOR: Profª. Drª. Gabriela Salatino Liedke

**Background:** The loss of upper posterior teeth leads to bone resorption and maxillary sinus pneumatization, often preventing immediate insertion of dental implants and leading to the need for sinus floor augmentation (SFA) and bone graft. **Objective:** To evaluate, in cone-beam computed tomography (CBCT) images, the volumetric changes in the alveolar ridge and maxillary sinus after bone grafting for SFA and dental implants placement. **Materials and methods:** Bone and sinus volume of 16 maxillary sinuses of 12 patients submitted to SFA, bone graft, and implant placement were evaluated. CBCT exams were performed three times: evaluation of the residual bone (T0), evaluation of the graft after SFA before implant surgical planning (T1), and evaluation after implants healing (T2). All DICOM formatted images were evaluated by two calibrated examiners (ICC > 0.9) using ITK-SNAP software. The volume measured at each time point was compared using the ANOVA test. Clinical and demographic variables were collected and the percentage of bone gain and resorption were compared using the t-test. The significance level considered was $P < 0.05$. **Results**: The bone volume showed a significant increase after SFA (T1), with also significant resorption (T2); the sinus volume showed a significant reduction after SFA (T1) but with volume maintenance over time (T2). Sites with volumetric variation at T1 greater than 200% had lower longitudinal resorption ($p=0.036$), with no association with clinical or demographic variables ($p > 0.05$). **Conclusion:** The present study found an average increase of 200% in the bone ridge after SFA and an average resorption of 11% over four years, after implant placement, concentrated in the cervical region of the implants. Bone gain and resorption of the graft volume were not associated with the clinical or demographic variables of the patients.



**Keywords:** Bone Grafting. Sinus Floor Augmentation. Dental Implant. Cone-Beam Computed Tomography.

**SUMÁRIO**

## INTRODUÇÃO E REVISÃO DE LITERATURA

Ausências dentárias são uma condição prevalente no mundo e tanto o edentulismo total quanto as perdas dentais unitárias merecem atenção e tratamento (PERES MA et al., 2019). Especificamente, a perda dos dentes superiores posteriores muitas vezes leva à reabsorção óssea e aumento da pneumatização do seio maxilar (ZIJDERVELD et al., 2009). Com esta condição clínica, a inserção imediata do implante torna-se consequentemente difícil devido à insuficiência do volume ósseo na região (PJETURSSON et al., 2008).

Desse modo, para permitir a inserção do implante, é necessário corrigir previamente a atrofia do processo alveolar da maxila. Várias técnicas foram descritas para aumentar o volume alveolar, incluindo enxerto interposicional após osteotomia de Le Fort I, enxerto ósseo onlay e levantamento de seio maxilar (LSM) (CHIAPASCO; ZANIBONI, 2009; MUÑOZ-GUERRA; NAVAL-GÍAS; CAPOTE-MORENO, 2009; NYSTRÖM et al., 2002; UMANJEC-KORAC et al., 2014).

A técnica de enxerto interposicional após osteotomia de Le Fort I caracteriza-se por corrigir a relação interarco, sendo utilizada, assim, em casos com retrusão significativa devido à atrofia óssea. Essa técnica, porém, é mais invasiva que o enxerto ósseo onlay e levantamento de seio maxilar, o que resulta em maior risco cirúrgico para o paciente e tempo de recuperação mais lento (SCHLUND et al., 2016).

O levantamento de seio maxilar (LSM), por sua vez, envolve a redução da cavidade sinusal, visando à produção de osso dentro de um espaço que anteriormente era uma porção do seio maxilar (SANTAGATA et al., 2014). Ele pode ser realizado pela técnica da janela lateral ou com osteótomos de Summer. A primeira técnica é um procedimento eficaz para obter altura óssea e facilitar a futura colocação do implante em uma maxila posterior atrófica pneumatizada, porém possui maior incidência de complicações trans e pós-operatórias, como perfuração da membrana sinusal e infecção (CHIAPASCO; ZANIBONI, 2009; JENSEN; TERHEYDEN, 2009). Já o LSM utilizando osteótomos de Summers é considerado menos invasivo e menos traumático, porém a técnica necessita de uma altura mínima do rebordo de 6 mm para ser utilizada (BRÄGGER et al., 2004; TROMBELLI et al., 2010).

Atualmente, vários tipos de materiais para enxerto podem ser utilizados para correção de volume ósseo, tais como: osso autógeno (extraído do próprio paciente); osso alogênico (de outros doadores humanos); osso xenogênico (mineral ósseo desproteinizado de bovino); e materiais aloplásticos (hidroxiapatita e fosfato beta tricálcico) (BROWAEYS; BOUVRY; DE BRUYN, 2007). O osso autógeno é considerado o padrão ouro e pode ser colhido a partir de diferentes locais como a crista oblíqua mandibular, a sínfise da mandíbula, tuberosidade maxilar, crista ilíaca, platô da tíbia e o calvário (SMOLKA et al., 2006). Possui resistência à infecção, propriedades osteoindutoras e osteocondutoras e estimula o crescimento ósseo local. No entanto, apresenta desvantagens como a disponibilidade limitada, a morbidade no local doador, o longo tempo cirúrgico, taxas de reabsorção rápidas e imprevisíveis, principalmente para locais doadores extrabucais, como o osso ilíaco; que tem a necessidade de anestesia geral e atuação de equipe multi profissional (AVILA et al., 2010; ORSINI et al., 2005).

Em relação aos demais substitutos ósseos, o osso bovino desproteinizado (osso xenogênico) apresenta o melhor desempenho biológico, possuindo resultados semelhantes aos do osso autógeno, uma vez que sua porosidade associada à capacidade osteocondutora permite a integração ao tecido hospedeiro, a colonização dos osteoblastos e a neoformação óssea (SCARANO et al., 2006). Além disso, suas taxas de reabsorção são consideravelmente menores do que as do osso autógeno (SCHWARTZ et al., 2007).

Em uma revisão sistemática realizada por Shanbhag, S., Shanbhag, V. e Stavropoulos (2014) foi verificado que quando é utilizado somente o osso autógeno na forma de partículas ou blocos, podem ocorrer reduções consideráveis de volume (média de aproximadamente 45%) ao longo do tempo (6 meses a 2 anos). Já, quando são utilizados substitutos ósseos, como minerais ósseos bovinos ou fosfato de cálcio bifásico isoladamente ou em combinação com o osso autógeno, as reduções médias de volume são de aproximadamente 18% a 23%. Independentemente, a reabsorção esperada do enxerto e neoformação óssea não parecem comprometer a inserção dos implantes nem sua sobrevida a longo prazo.

Para avaliar o volume do enxerto e acompanhar a taxa de reabsorção, faz-se necessário a utilização de exames por imagem. A taxa de reabsorção pode ser

avaliada através de uma radiografia panorâmica. No entanto, exames radiográficos, apesar da menor dose de radiação, fornecem apenas uma imagem bidimensional de estruturas tridimensionais, comprometendo a avaliação da profundidade tecidual no planejamento em Implantodontia. Assim, atualmente, a tomografia computadorizada de feixe cônico (TCFC) é a recomendação para planejamento de reabilitações orais com implantes osteointegrados e cirurgia de LSM, sendo considerado um método essencial para analisar o rebordo ósseo, apresentando a oportunidade de realizar não apenas medições lineares, mas também avaliações volumétricas (SEDENTEXCT, 2012; JACOBS et al. 2018). Ainda, Bacuit et al. (2012) compararam a TCFC com radiografias panorâmicas no planejamento pré-operatório de implantes em combinação com procedimentos de enxerto sinusal e verificaram uma taxa de detecção maior de sinusitepatias quando utilizada a TCFC. Sendo assim, um planejamento cirúrgico utilizando a TCFC resultaria em aumento da confiança cirúrgica e menor risco de complicações.

Desse modo, para monitorar e acompanhar com precisão as alterações no volume do enxerto ao longo do tempo é necessário utilizar imagens de tomografia computadorizada. Umanjec-Korac et al. (2016) avaliaram a precisão da TCFC na medição de alterações no volume de enxerto ósseo autógeno em cadáveres humanos. Esse estudo apontou que, em todos os casos, a TCFC superestimou o volume do enxerto maxilar em comparação com a Micro-TC, que foi utilizada como padrão ouro. No entanto, as diferenças de medida foram limitadas e podem não influenciar o desempenho clínico. A literatura aponta a TCFC como um método confiável para avaliação óssea, apresentando a oportunidade de realizar não apenas medições lineares, mas também avaliações em três dimensões (3D) (MAZZOCO et al., 2014). Além disso, possui alta resolução espacial e boa resolução de contraste para tecidos duros, permitindo identificação do tecido ósseo e material do enxerto (MAZZOCO et al. 2014; UMANJEC-KORAC et al. 2016; PIGNATON et al. 2018).

Dependendo da qualidade e quantidade do osso residual, os implantes podem ser colocados simultaneamente com o enxerto (cirurgia de estágio único) ou após um período de cicatrização (protocolo de dois estágios) (BROWAEYS; BOUVRY; DE BRUYN, 2007; PJETURSSON et al., 2008). Mazzocco et al. (2014) avaliaram a alteração volumétrica de osso bovino anorgânico enxertado nos seios maxilares de 18 pacientes. Em 8 pacientes foi realizada a inserção imediata de

implantes e em 10 pacientes a inserção tardia, não sendo observada diferença estatística nos valores de volume entre os dois grupos. Além disso, apesar de haver redução de volume do enxerto, esta não prejudicou a estabilidade dos implantes. Em uma revisão sistemática realizada por Shanbhag, S, Shanbhag, V. e Stavropoulos (2014) foi apontado que na maioria dos casos, as reduções de volume do enxerto não comprometem a taxa de sobrevivência de implantes colocados sob protocolo de dois estágios. Nessa revisão, apenas um estudo não controlado relatou colocação simultânea de implante. Portanto, ainda não está claro se a colocação simultânea do implante contribui para maior perda de volume em comparação com um procedimento em dois estágios.

Outro aspecto importante a ser destacado é que, até então, a TCFC tem sido utilizada principalmente para avaliar o volume do enxerto inserido e sua taxa de reabsorção. No entanto, alguns autores comentam sobre a necessidade de avaliação do volume sinusal (HATANO et al. 2004; BERBERI et al. 2014; KIRMEIER et al 2018), ainda pouco explorado.

O crescente uso da TCFC na prática odontológica, somado a sua capacidade de avaliar volume a partir da utilização de softwares específicos, tem potencial para contribuir com o diagnóstico e o planejamento das reabilitações com enxerto ósseo após LSM e implantes dentários. Assim, é de interesse investigar o comportamento da estabilidade e manutenção dos enxertos ósseos sinusais após a instalação dos implantes. Neste sentido, o objetivo deste estudo retrospectivo foi avaliar, em imagens de TCFC, as alterações volumétricas no rebordo alveolar e no seio maxilar após a realização da cirurgia de LSM, enxerto ósseo e instalação de implantes dentários, correlacionando os dados volumétricos com variáveis clínicas e demográficas dos pacientes.

## 2 ARTIGO

Esta dissertação está apresentada em formato de artigo científico, conforme periódico **Clinical Oral Implants Research** - ISSN 1600-0501 (Anexo B).

# ALVEOLAR AND MAXILLARY SINUS VOLUMETRIC QUANTIFICATION AFTER SINUS LIFT, BONE GRAFT, AND IMPLANT PLACEMENT USING CBCT

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## ABSTRACT

**Objective:** To quantify in cone-beam computed tomography (CBCT) images, the volumetric changes in the alveolar ridge and the maxillary sinus after sinus lift (SL), inorganic bovine graft, and implant placement.

**Methodology:** A retrospective analysis of 16 maxillary sinuses from 12 was conducted. CBCT exams were performed three times: evaluation of the residual ridge (T0), evaluation of the graft after SL before implant surgical planning (T1), and evaluation after implant healing (T2). DICOM images were used to calculate alveolar ridge and maxillary sinus volumes by two calibrated examiners (ICC > 0.9) using ITK-SNAP software. The volume measured at each time point was compared using ANOVA test. Clinical and demographic variables were collected from patients' records, and the percentage of bone gain and resorption were compared using t-test. The significance level considered was $P < 0.05$.

**Results**: Bone volume showed a significant increase after SL (T1) and also a significant resorption (T2); sinus volume showed a significant decrease after SL (T1) but no re-pneumatization over time (T2). Sites with volumetric variation at T1 greater than 200% had lower longitudinal resorption at T2 ($p=0.036$). Clinical and demographic variables had no association with bone gain nor resorption ($p > 0.05$).

**Conclusion:** The present study found an average increase of 200% in the alveolar ridge volume after SL and an average resorption of 11% over four years, after implant placement, concentrated in the cervical region of the implants. Bone gain and graft resorption volume were not associated with clinical or demographic variables of the patients.


**Keywords:** Bone Grafting. Dental Implant. Cone-Beam Computed Tomography. Maxillary sinus lift.

## INTRODUCTION

Tooth loss is a prevalent condition in the world and either the total edentulism or unitary losses need attention and treatment (Peres et al., 2019). Specifically, the loss of upper posterior teeth often leads to bone resorption and increased pneumatization of the maxillary sinus (Zijderveld et al., 2009). With this clinical condition, implant placement becomes difficult due to insufficient bone high in the region (Pjetursson et al., 2008). Therefore, to allow patient rehabilitation with dental implants, it is necessary to correct previously the atrophy of the maxillary alveolar process. Several techniques (Le Fort I osteotomy, onlay bone graft, and maxillary sinus lift) with the use of diverse types of graft materials (autogenous bone, allogeneic bone, xenogenic bone, and alloplastic materials) are available for alveolar volume correction (Nyström et al., 2002; Pignaton et al., 2019).

Patient's diagnosis and planning for sinus lift (SL) and bone graft include clinical and imaging evaluations. In fact, imaging exams have a role for evaluation of the residual ridge and the volume of bone graft needed, as well as for monitoring the graft resorption rate and subsequent implant planning, and the longitudinal implant stability after osseointegration. Radiographic exams, despite the lower radiation dose, provide only a two-dimensional assessment of three-dimensional structures, compromising the evaluation of the tissue width in Implantology. Therefore, currently, cone-beam computed tomography (CBCT) is the exam of choice for the oral rehabilitation planning with osseointegrated dental implants and maxillary SL surgery. CBCT allows the opportunity to perform high and width linear measurements, as well as volumetric quantification of the alveolar ridge and the maxillary sinus (Sedentexct guidelines, 2012; Jacobs et al., 2018). In addition, it has high spatial resolution and a good contrast resolution for hard tissues, allowing the identification of bone tissue and graft material (Pignaton, et al., 2019; Mazzocco, et al., 2014; Umanjec-Korac et al., 2016).

In a systematic review, Shanbhag et al. (2014) determined that, when only autogenous bone is used, considerable volume reductions might occur (approximately 45%) over time (6 months to 2 years); on the other hand, when bone substitutes are used, such as inorganic bovine bone, the volume resorption average is between 18% and 23%. Every SL surgery demands the resorption of the bone graft used and the consequent individual bone neoformation. Thus, histologically, in graft areas, it is possible to observe, besides the remaining bone ridge, newly formed bone tissue, grafted material (inorganic), and soft tissue (Pignaton, et al., 2019), which, on imaging exams, are visualized as a single region. Nevertheless, the expected graft resorption and the bone neoformation do not seem to compromise implant insertion or its long-term survival (Shanbhag et al., 2014).

Another important aspect to be highlighted is that, previously, CBCT has been used mainly to assess the volume of the inserted sinus graft and its resorption rate. However, some authors comment on the need to assess the sinus volume (Hatano et al., 2004; Kirmeier et al., 2008), still little explored. The growing use of CBCT in dental practice, combined to its ability to assess volume when dedicated software are used, has the potential to contribute to the diagnosis, planning, monitoring, and understanding of oral rehabilitations with SL and dental implants. In this manner, it is of interest to investigate the stability behavior and maintenance of bone grafts after implant placement.

In this sense, the purpose of this retrospective study was to evaluate, in CBCT images, the volumetric changes in the alveolar ridge and maxillary sinus after SL surgery, inorganic bone grafting, and implant placement, correlating the volumetric data with clinical and demographic variables of the patients.

## METHODOLOGY

### Ethical aspects

The research protocol of this study was approved by the Research Ethics Committee of the General Hospital of Santa Maria (HGSM) and of the Federal University of Santa Maria School of Dentistry (protocol number CAAE44943321.3.0000.5346) and it is in accordance with the World Medical Association Declaration of Helsinki.

### Study Design and Sample

A retrospective study was carried out with all CBCT images from patients submitted to SL surgery, inorganic bone grafting, and late implant placement between 2015 and 2021. The exams were requested for diagnosis, planning, and monitoring of bone grafting and dental implant procedures and were stored at the Dental Radiology sector of the HGSM. Clinical and demographic data were collected from the patients' dental records.

CBCT images with acquisition errors, which did not present the entire graft region, or whose patient did not have all the stages evolved in the medical record registered in the HGSM files were excluded.

**CBCT acquisitions**

All CBCT exams were performed on the Orthopantomograph OP300 equipment (Instrumentarium Dental, Tuusula, Finland). The patient's positioning followed the manufacturer's recommendations: patient with median sagittal plane perpendicular to the ground and teeth occlusal plane parallel to the ground, aligned in the region of interest (posterior maxilla). The acquisition parameters used were 3.24 mAs, 110 kVp, 20 s, 6 x 8 cm acquired region, and 0.2 mm voxel. The same acquisition protocol was used in all clinical evaluation stages.

Three CBCT scans were analyzed for each selected case: diagnosis and surgical planning of SL and graft (T0), evaluation of the graft after SL, and surgical planning of the dental implant (T1), and longitudinal evaluation of the dental implant (T2).

**Surgical Procedures**

All surgical procedures were performed by the same professional, specialist in Implantology, after careful physical, clinical, and imaging evaluation of the patient. All patients presented a residual bone height < 5 mm (evaluated in the cross-sectional image from CBCT).

SL was performed using the side window technique. Under local anesthesia, a full-thickness incision and flap was performed to expose the buccal cortex of the maxillary sinus. An oval shaped window was created with a straight piece and a #6 round-shaped diamond bur with abundant irrigation using 0.9% saline solution. The sinus membrane was exposed and gently dissected with curettes (Neodent, Curitiba, Brazil). The buccal bone was then displaced to medial and superior, elevating the floor of the maxillary sinus. The space created was filled exclusively using inorganic bone graft (Bio-oss; Geistlich, Wolhusen, Switzerland), in quantity enough to reach a height of 10 to 12 mm, aiming the latter placement of a 10 mm implant, with its apex completely covered by grafting material. A collagen membrane (Bio-Gide; Geistlich, Wolhusen, Switzerland) was placed over the buccal window to prevent graft migration and soft tissue invasion. The soft-tissue flap was replaced with tension-free sutures (Nylon 4-0). The suture was removed in 14 days. Patients were prescribed Amoxicillin (875 mg), twice a day, 3 days before surgery and 4 days after the surgery, Flancox (400 mg), twice a day, for 5 days, Dipyrone (1g), up to 4 times a day, and told to rinse with chlorhexidine 0.12% twice a day for 1 week.

After the healing process, and a second CBCT examination (T1), Cone Morse or Gran Morse dental implants, all conical (Neodent, Curitiba, Brazil) were inserted in the grafted region. The sequence of drilling and torque for implant placement followed the protocol as recommended by the manufacturer. The implants were left unloaded and covered by soft tissues (with no immediate functional load). Suture was performed (Nylon 4-0). Patients were prescribed Amoxicillin (2g) one hour before surgery, Flancox (400 mg), twice a day, for 5 days, Dipyrone (1g), up to 4 times a day, and told to rinse with chlorhexidine 0.12% twice a day for 1 week.

Prosthetic rehabilitation was conducted after a minimum period of implant osseointegration of six months. The success of the procedure (absence of mobility, absence of symptoms and absence of a radiolucent line between the implant and the bone tissue) was verified by clinical and CBCT evaluation (T2).

**CBCT Volumetric Evaluation**

All CBCT images (T0, T1, and T2) were exported in DICOM format and evaluated by two trained and calibrated examiners using ITK-SNAP software (University of Pennsylvania, Philadelphia, PA, USA). The training consisted of a meeting to define concepts and anatomic landmarks. Calibration consisted of the evaluation of nine exams, twice, with a seven-day interval. The intra- and inter-examiner agreement, according to the Intraclass Correlation Index (ICI), was greater than 0.9.

The methodology for evaluating the volume was as described: first, the area of interest, comprising the rehabilitated region and 20 mm from the crest of the bone ridge to the interior of the maxillary sinus, was delimited in the sagittal plane. The sagittal plane was used for the mesiodistal delimitation of the interest area and the axial plane for the buccolingual delimitation (Figure 1). After delimitation, the region was segmented from the total volume to calculate the volume (in $mm^3$). The measurement of the maxillary sinus was performed with a semi-automatic tool, with manual refinement. Hard tissues measurement was performed with the manual segmentation tool. At T0, only the residual ridge was present for segmentation (Figure 2a); at T1, the bone ridge and the graft material were segmented (Figure 2b); finally, at T2, the bone ridge, the graft material, and the implant, when inserted into the bone tissue, were included in the segmentation (Figure 2c).

The axial, coronal, and sagittal planes were adjusted and aligned based on the center of the implant long axis, assuring all three evaluated images would present the same region.

The 'zoom' and 'brightness-contrast' tools were available to permit better identification of structures and demarcation of the cavities.

**Clinical and demographic data**

Clinical and demographic variables were collected from the patients' dental records. Demographic data included gender (female and male) and age (collected in years). Clinical data included systemic impairment (including smoking), history of periodontal disease, and presence of prosthetic rehabilitation in the implant. The dates when the graft, implant, and prosthesis procedures were performed were also registered, allowing the time elapsed evaluation since the treatments were carried out. The follow-up time was the time between the SL graft and the T2 CBCT scan, indicating the longitudinal follow-up of the patient. The prosthetic time, calculated only for those patients who had already experienced prosthetic rehabilitation and indicating the time that the implant was under functional loading, was calculated between the prosthesis installation and the T2 CBCT scan.

**Data analysis**

Statistical evaluation was performed using Microsoft Office Excel (Microsoft Corp, Redmond, WA, USA) and SPSS (SPSS Inc., Chicago, IL, USA) programs. Statistical significance was set at 5% ($p < 0.05$).

The primary outcome evaluated was bone and maxillary sinus volume calculated at T0, T1, and T2. After normality evaluation (Kolmogorov–Smirnov), the groups were compared using repeated measures ANOVA followed by Bonferroni post-test.

Percentages of bone gain and resorption were calculated and compared between each clinical and demographic variable collected, using the t-test for independent samples. The mean variations of bone gain at T1 and of bone resorption at T2 were used as a cutoff point for dichotomizing these variables, and their association was verified using the chi-square test.

**Figure 1.** Area of interest defined in the sagittal (a), axial (b), and coronal (c) planes in an initial tomography (T0).

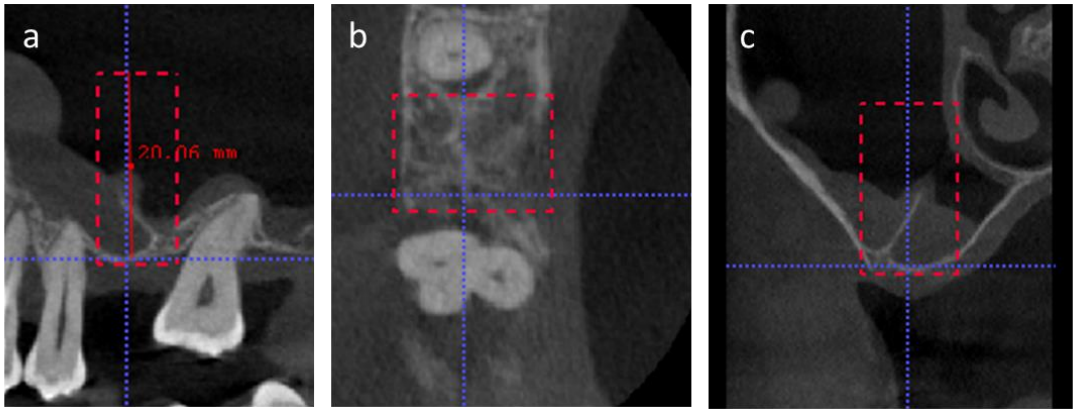
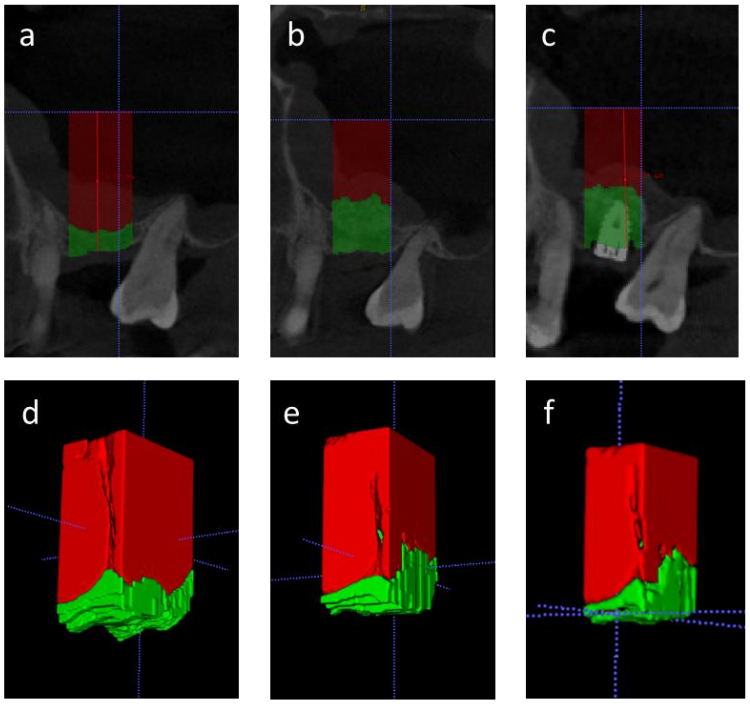



**Figure 2.** Sagittal sections (a-c) and volumetric segmentations of the maxillary sinus region (in red) and ridge (in green) at times T0 (a/d), T1 (b/e), and T2 (c/f).



## RESULTS

Bone and sinus volume of 16 maxillary sinuses of 12 patients were evaluated. Clinical, tomographic, and demographic data are presented in Table 1**.** All dental graft and implant procedures were successful. Seven out of 16 implants installed were rehabilitated with dental prosthesis and submitted to functional loading.

**Table 1.** Demographic, clinical and tomographic information of the sample.

| Variable | N (%) | Avarage (Min-Max) |
|---|---|---|
| *Demographic and clinical variables (N= 12)* | | |
| Gender | | |
| Female | 6 (50%) | |
| Male | 6 (50%) | |
| Age (years) | | 55.8 (49 – 67) |
| Systemic impairment | | |
| Absent | 8 (66.7%) | |
| Present | 4 (33.3%) | |
| Periodontal disease | | |
| Absent | 9 (75%) | |
| Present | 3 (25%) | |
| Dental prosthesis (n = 16) | | |
| Absent | 9 (56.3%) | |
| Present | 7 (43.8%) | |
| Tomographic variables (n = 16) | | |
| Bone Volume ($mm^3$) | | |
| T0 | | 457.53 (104.1 – 1232) |
| T1 | | 1134.84 (546.7 – 2381) |
| T2 | | 1032.39 (433 – 2137) |
| Sinus volume ($mm^3$) | | |
| T0 | | 1639.57 (460.2 – 3218) |
| T1 | | 1080.9 (208 – 1907) |
| T2 | | 1126.18 (380 – 1847) |
| Bone gain at ($mm^3$) | | 684 (298.4 – 1751.7) |
| Bone gain at (%) | | 201.51 (50.57– 458.54) |
| Bone resorption at T2 ($mm^3$) | | 122 (9.5 – 319) |
| Bone resorption at T2 (%) | | 11.74 (1.03 – 21.30) |
| Follow-up (months) | | 29.37 (7 – 60) |
| Prosthetic time (months) (n=7) | | 21.14 (3 – 43) |

N, number of patients; n, number of grafts. T0, CBCT for diagnosis and surgical planning of SL graft; T1, CBCT for graft evaluation after SL and dental implant surgical planning; T2, CBCT for longitudinal evaluation of the dental implant.

Bone and sinus volumes are shown in Table 2. The bone ridge has shown a significant increase after SL and inorganic bone graft (T1), with also significant bone resorption (T2). Regarding sinus volume variation, a significant reduction was observed after SL (T1) but no re-pneumatization over time (T2).

**Table 2.** Comparison of the mean volume ($mm^3$) of the ridge and the maxillary sinus for each evaluated time (intra-group comparison).

| Variable | Volume | | | P value |
|---|---|---|---|---|
| | T0 | T1 | T2 | |
| Bone Volume | 457.53 **A** | 1134.84 **B** | 1032.39 **C** | 0.000 |
| Sinus Volume | 1639.57 **A** | 1080.90**B** | 1126.18**B** | 0.000 |

T0, CBCT for diagnosis and surgical planning of SL graft; T1, CBCT for graft evaluation after SL and dental implant surgical planning; T2, CBCT for longitudinal evaluation of the dental implant; P value, repeated measures ANOVA followed by Bonferroni post-test; different letters indicate statistical difference between the groups.

Table 3 indicates the result of the association between the gain (T1) and the resorption (T2) of the bone graft volume. Sites that showed a volumetric variation at T1 greater than 200% had lower longitudinal resorption (p=0.036).

**Table 3:** Association between the volumetric variation percentage observed on bone graft at T1 and T2 (n = 16).

| | % Resorption (T1-**T2**) | |
|---|---|---|
| | > 11 | < 11 |
| % Bone gain (**T1**-T0) | | |
| > 200 | 1 | 6 |
| < 200 | 6 | 3 |
| P value | | 0.036 |

T0, CBCT for diagnosis and surgical planning of SL graft; T1, CBCT for graft evaluation after SL and dental implant surgical planning; T2, CBCT for longitudinal evaluation of the dental implant; P value, chi-square test.

Table 4 indicates that the means of bone gain or resorption between the clinical and demographic variables evaluated did not present statistical differences (p > 0.05). Although implants submitted to functional load had a mean resorption in the graft volume of 15.4% and those not submitted had a resorption of 8.9%, the difference between groups was not statistically significant (p = 0.067).

**Table 4.** Variation in bone gain (T1) and bone resorption (T2) considering clinical and demographic variables.

| Variable | Bone gain (%) (**T1**-T0) | P | Bone resorption (%) (T1-**T2**) | P |
|---|---|---|---|---|
| Gender | | | | |
| Female | 156.50 | 0.20 | 10.37 | 0.46 |
| Male | 246.52 | | 13.11 | |
| Age | | | | |
| < 56 years old | 198.66 | 0.89 | 10.28 | 0.16 |
| > 56 years old | 210.07 | | 16.12 | |
| Systemic impairment | | | | |
| Absent | 212.06 | 0.66 | 10.42 | 0.28 |
| Present | 178.29 | | 14.65 | |
| Periodontal disease | | | | |
| Absent | 179.11 | 0.27 | 10.18 | 0.13 |
| Present | 268.72 | | 16.43 | |
| Dental prosthesis | | | | |
| Absent | | | 8.90 | 0.067 |
| Present | | | 15.39 | |
| Follow-up | | | | |
| < 29 months | | | 10.09 | 0.24 |
| > 29 months | | | 14.49 | |

P value, t test for independent samples.

## DISCUSSION

Implantology aims to rehabilitate the patient, restoring function and esthetics and providing a better quality of life. Tooth loss inevitably leads to alveolar bone resorption, which in the case of upper posterior teeth is accompanied by pneumatization of the maxillary sinus floor (Zijderveld, et al., 2009; Jensen & Terheyden, 2009), hindering implant placement and leading to the need for bone grafts (Pjetursson et al., 2008). The longitudinal evaluation of the behavior and maintenance of these bone grafts after implant placement and prosthetic rehabilitation is fundamental. Hence, this retrospective study evaluated the volumetric changes of the grafted areas after SL surgery, since the bone volume stability represents a fundamental factor for the stability and, consequently, longevity of implants.

Bone graft surgeries resulted in a mean increase of 200% (± 137) in alveolar ridge volume. As expected, studies with similar methodologies also have found bone recovery allowing the rehabilitation of patients with integrated bone dental implants, but the majority did not quantify the bone gain. After a follow-up period of 21 months, a mean resorption of 11% (± 7) of the initially achieved volume was observed. In addition, sites with a volumetric variation greater than 200% after bone grafting (T1) had less longitudinal resorption at T2,

suggesting that the residual ridge volume quantification might be an important measure for planning the graft material needed.

Studies report bone resorption ranging from 6.3% to 39.20% after 4 to 48 months after SL surgery (Umanjec-Korac et al., 2014; Mazzocco et al., 2014; Berberi et al., 2015; Kirmeier et al., 2008; Jensen et al., 2009; Sbordone et al., 2013; Santagata et al., 2014). The values reported in the literature are higher than the 11% found in this study, since previous studies considered the total volume of the graft in the comparison. On the other hand, this research evaluated longitudinal resorption having the starting point the volume available for implant planning. Klein et al., unlike previous studies, have observed a 9.1% gain in bone volume when compared to the volume immediately after SL and eight months of follow-up.

In this study, bone augmentation was performed using the lateral window surgical technique, inorganic bone graft, and late implant insertion, since the available alveolar remnant was less than 5 mm in height. Despite the observation of longitudinal bone resorption and reduction in bone volume at T2, no implant was lost, and all prostheses remained in function during the follow-up period of this study (3 to 43 months). Although related to greater bone resorption adjacent to the cervical margin of the implants, the presence of prosthetic rehabilitation did not show any statistical difference with the non-rehabilitated group.

Aspects such as the choice of the SL technique, the graft material used, and the moment of the implant insertion may be related to the extent of implant marginal resorption and of the graft itself. Sbordone et al. (2011), compared immediate and late implant insertion performed with bovine graft or autologous bone and verified that the late implant group had greater marginal cervical resorption to the implants, regardless of the graft type. However, Mazzocco et al. (2014) found no difference in graft volume due to the installation of immediate or late implants. Regarding the type of graft used, Sbordone et al. (2013), verified less resorption for the block graft compared to the particulate grafts in a six-year follow-up. In contrast, the data obtained from both studies suggest that the remodeling observed during long-term follow-up does not appear to affect the implant survival rate.

Pneumatization of the sinus floor after tooth loss is a known phenomenon, but the re-pneumatization after SL must still be studied (Hatano et al., 2004; Kirmeier et al., 2008). Thus, in addition to bone volume evaluation, the corresponding volume of the maxillary sinus was also calculated and compared in the three experimental times. There was a reduction in the volume of the maxillary sinus after grafting (T1), as expected, and maintenance of its volume over time (T2). Only one research also assessed the volume of the maxillary sinus, verifying a reduction in sinus volume. This reduction in sinus volume, reported by Berberi et

al. (2015), may be explained by the more apical dental implant placement, occupying an area initially without graft. In the current study, all implants were placed inside the graft material, and thus the maintenance in sinus volume at T1 and T2 suggests that bone resorption occurred in the residual ridge, adjacent to the implants' platform. Bone resorption adjacent to implants after functional load are common (Kim et al., 2009; Natto et al., 2019) and, although normally evaluated on radiographs with linear measurements, it is expected that the volumetric evaluation also demonstrate the marginal bone resorption to the implants and, consequently, the decrease in bone volume. This finding reinforces the importance of a good peri-implant tissue health maintenance for the longevity of implant rehabilitations.

Patients' clinical and demographic characteristics influence the success of the treatment and maintenance of bone volume acquired after grafting and its longitudinal maintenance (Sbordone et al., 2013; Klijn et al., 2012). However, in this study, none of the collected variables (gender, age, systemic involvement, or history of periodontal disease) showed association with the outcomes studied at T1 (increase in bone volume after grafting) nor at T2 (resorption of bone volume after implant placement and dental prosthesis). Nevertheless, the heterogeneity of the sample and its reduced size may have weaken this analysis.

This study used a convenience sample collected from a clinical dental center with a continuous patient flow. Hence, although the same professional has performed all surgical and prosthetic procedures, it was not possible to manage other variables, such as the time taken to implant placement or to prosthetic rehabilitation, as verified in other studies (Berberi et al., 2015; Sbordone et al. 2013; Klein et al., 2016; Sbordone et al., 2011; Klijn et al., 2012). Furthermore, in this study, the CBCT scan was not performed immediately after the bone graft, since in a real clinical setting it is necessary to know the condition of the alveolar ridge at the time of the implant placement, which only occurs after the graft healing period. Another disadvantage inherent at this and other studies that measured bone graft adjacent to dental implants is the presence of metal artifacts in the tomographic image (Schulze et al., 2011), that can jeopardize the delimitation of structures.

CBCT is an accurate method for volumetric assessment (Umanjec-Korac et al. 2016), and it has been used by several studies as a promising approach to quantify changes over time in regions recovered after SL (Mazzocco et al., 2014; Berberi et al. 2015; Kirmeier et al., 2008; Klein et al., 2016; Sbordone et al., 2011). ITK-SNAP (Yushkevich et al., 2006) software used in this study is a measurement tool allowing semi-automatic and manual segmentation of the region of interest. Considering that CBCT equipment does not use Hounsfield unit to measure density (Pauwels et al., 2015), semi-automatic segmentation cannot always be

accurately used for low contrast regions. Thus, for the segmentation of the alveolar ridge and the grafted area, the manual segmentation was used, having the sagittal plane as reference. Manual segmentation requires freehand drawings, which can be sensitive to the examiner's analysis. To minimize this bias, the same examiner evaluated the three exams of each patient in sequence. In addition, training and calibration process, with high intra- and inter-examiner reproducibility (ICC > 0.9), was verified. For the maxillary sinus segmentation, considering its high contrast with the adjacent tissues, semi-automatic segmentation was used.

Studies indicate the importance of longitudinal follow-up of implants placed in bone graft areas, as well as they have been trying to understand the resorption pattern of this graft for better patient treatment. The pattern of volumetric change between bone graft and maxillary sinus present by this study suggests that the observed longitudinal resorption occurs at the implant crest level, since the volume of the maxillary sinus remained constant. Moreover, patients' clinical and demographic variables did not influence the volume variations observed in bone grafts, even though this results should be carefully interpreted considering the limited sample size, and other studies are recommended for a better understanding of these associations.

## CONCLUSION

The present study obtained an average increase of 200% in the alveolar ridge after SL surgery and an average resorption of 11% of its volume over four years after implant placement, concentrated in the cervical region of the implants. Within the limits of a retrospective evaluation, it was verified that bone gain and maintenance of the graft volume were not associated with patients' clinical or demographic variables.

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## 3 CONSIDERAÇÕES FINAIS

A literatura mostra a importância do acompanhamento longitudinal dos implantes dentários realizados em regiões de enxerto ósseo e LSM. Estudos realizados com radiografias e tomografias vêm tentando conhecer o padrão de reabsorção do enxerto para melhor tratamento dos pacientes. O uso da TCFC, juntamente com o aplicativo ITK-SNAP, forneceu uma combinação de ferramentas manuais e semiautomáticas que permitiu avaliar volumétricamente a região de interesse e extrair informações relevantes para colaborar com o entendimento disponível sobre o tema.

Através dos resultados deste estudo podemos observar que:

- A correção da pneumatização do seio maxilar com LSM e enxerto ósseo bovino foi satisfatória para permitir a inserção e a manutenção dos implantes dentários, sem evidências de qualquer associação negativa entre a reabsorção do volume do enxerto com as taxas de sobrevivência dos implantes inseridos tardiamente ao enxerto (cirurgia de dois estágios), conduzindo o procedimento a um sucesso clínico de longo prazo.

- O volume enxertado durante o LSM acima de 200% demostrou ser clinicamente benéfico para compensar a redução de volume, pois esses locais apresentaram uma menor reabsorção longitudinal (p=0,036).

- O padrão volumétrico entre região enxertada e seio maxilar sugere que a reabsorção longitudinal do enxerto ósseo concentra-se na região cervical dos implantes. Este achado reforça a importância da higiene e manutenção da saúde dos tecidos peri-implantares para a longevidade da reabilitação com implantes.

- Apesar dos implantes submetidos à carga funcional terem apresentado uma reabsorção média superior aos implantes sem carga, esta diferença não foi estatisticamente significativa. (p =0,067).

- Ficou demostrado também que variáveis clínicas ou demográficas dos pacientes parecem não influenciar com o ganho ósseo e a reabsorção do volume enxertado.

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# ANEXOS

## ANEXO A – Aprovação no Comitê de Ética em Pesquisa (CEP)

UNIVERSIDADE FEDERAL DE SANTA MARIA/ PRÓ-REITORIA DE PÓS-GRADUAÇÃO E PESQUISA

**PARECER CONSUBSTANCIADO DO CEP**

**DADOS DO PROJETO DE PESQUISA**

**Título da Pesquisa:** QUANTIFICAÇÃO VOLUMÉTRICA DO REBORDO ALVEOLAR APÓS REANATOMIZAÇÃO DO ASSOALHO DO SEIO MAXILAR E INSTALAÇÃO DE IMPLANTES

**Pesquisador:** Gabriela Salatino Liedke

**Área Temática:**

**Versão:** 1

**CAAE:** 44943321.3.0000.5346

**Instituição Proponente:** Departamento de Estomatologia

**Patrocinador Principal:** Financiamento Próprio

**DADOS DO PARECER**

**Número do Parecer:** 4.647.006

**Apresentação do Projeto:**

Projeto de pesquisa do Programa de Pós-graduação em Ciências Odontológicas da UFSM. Trata-se de um estudo observacional retrospectivo com imagens de tomografia computadorizada de feixe cônico (TCFC) realizadas no Hospital Geral de Santa Maria (HgeSM) solicitadas para diagnóstico e acompanhamento pós-operatório dos casos de reabilitação com implantes dentários e levantamento de seio maxilar (LSM). Objetiva avaliar, por meio da TCFC, o volume ósseo alcançado no rebordo alveolar após a realização de LSM e a instalação dos implantes dentários, comparando com o volume ósseo inicial (pré-cirúrgico) e o volume ósseo após o enxerto sinusal. Os exames que serão utilizados foram solicitados com finalidade de diagnóstico, planejamento e acompanhamento dos procedimentos de enxerto ósseo e implantes dentários já realizados e encontram-se armazenadas no banco de dados do setor de Radiologia Odontológica do HGeSM e que foram realizados entre os anos de 2015 e 2020. Os dados serão analisados utilizando os programas Microsoft Office Excel (Microsoft Corp, Redmond, WA, USA) e SPSS (SPSS Inc., Chicago, IL, EUA). O nível de significância considerado será $P < 0,05$.

O projeto apresenta introdução e revisão de literatura, Objetivos, materiais e métodos, resultados esperados, orçamento, cronograma, referências, anexos e apêndices.

**Endereço:** Avenida Roraima, 1000 - Prédio da Reitoria - 7º andar - sala 763 - Sala Comitê de Ética - 97105-900 - Santa
**Bairro:** Camobi **CEP:** 97.105-970
**UF:** RS **Município:** SANTA MARIA
**Telefone:** (55)3220-9362 **E-mail:** cep.ufsm@gmail.com

**Objetivo da Pesquisa:**

GERAL: avaliar, por meio da TCFC, o volume ósseo alcançado no rebordo alveolar após a realização de LSM e a instalação dos implantes dentários, comparando com o volume ósseo inicial (pré-cirúrgico) e o volume ósseo após o enxerto sinusal.

ESPECÍFICOS:

1 - Comparar o volume ósseo i) do leito remanescente, ii) após o enxerto ósseo para levantamento do seio maxilar e iii) após implante em função, verificando o ganho e a manutenção do volume mensurado nos 3 tempos;

2- Comparar o volume da área correspondente ao seio maxilar i) previamente ao ato cirúrgico, ii) após o enxerto ósseo para levantamento do seio maxilar e iii) após implante em função;

3- Correlacionar o volume ósseo obtido pela cirurgia de LSM com dados clínicos e demográficos do paciente.

**Avaliação dos Riscos e Benefícios:**

Os riscos e benefícios estão descritos de forma suficiente nos documentos apresentados.

**Comentários e Considerações sobre a Pesquisa:**

.

**Considerações sobre os Termos de apresentação obrigatória:**

- Apresenta autorização institucional do cenário do estudo.
- Apresenta autorização institucional do Departamento de Odontologia da UFSM.
- Apresentou comprovação de registro no Gabinete de Projetos da Instituição de ensino.
- Apresenta solicitação de dispensa de TCLE com as devidas justificativas.
- Apresenta termo de confidencialidade devidamente assinado pela pesquisadora responsável.

**Recomendações:**

Veja no site do CEP - https://www.ufsm.br/pro-reitorias/prpgp/cep/ - modelos e orientações para apresentação dos documentos. Acompanhe as orientações disponíveis, evite pendências e agilize a tramitação do seu projeto.

**Conclusões ou Pendências e Lista de Inadequações:**

.

**Considerações Finais a critério do CEP:**

UNIVERSIDADE FEDERAL DE SANTA MARIA/ PRÓ-REITORIA DE PÓS-GRADUAÇÃO E PESQUISA

Continuação do Parecer: 4.647.006

Conheça o curso de qualificação dos comitês de ética em pesquisa que compõem o Sistema Cep/Conep em https://edx.hospitalmoinhos.org.br/project/cep.

**Este parecer foi elaborado baseado nos documentos abaixo relacionados:**

| Tipo Documento | Arquivo | Postagem | Autor | Situação |
|---|---|---|---|---|
| Informações Básicas do Projeto | PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1724656.pdf | 26/03/2021 10:21:13 | | Aceito |
| Projeto Detalhado / Brochura Investigador | Projeto.pdf | 26/03/2021 10:14:33 | Gabriela Salatino Liedke | Aceito |
| Outros | Registro_GAP_UFSM.pdf | 26/03/2021 10:14:16 | Gabriela Salatino Liedke | Aceito |
| Declaração de concordância | Comissao_Etica_Medica_HgeSM.pdf | 26/03/2021 10:13:43 | Gabriela Salatino Liedke | Aceito |
| Folha de Rosto | folhaDeRosto.pdf | 26/03/2021 10:11:54 | Gabriela Salatino Liedke | Aceito |
| Declaração de Instituição e Infraestrutura | AutorizUFSM.pdf | 26/03/2021 10:09:22 | Gabriela Salatino Liedke | Aceito |
| Outros | Confidencialidade.pdf | 26/03/2021 10:08:48 | Gabriela Salatino Liedke | Aceito |
| TCLE / Termos de Assentimento / Justificativa de Ausência | Dispensa_TCLE.pdf | 26/03/2021 10:07:48 | Gabriela Salatino Liedke | Aceito |

**Situação do Parecer:**
Aprovado

**Necessita Apreciação da CONEP:**
Não

SANTA MARIA, 13 de Abril de 2021

**Assinado por:**
**CLAUDEMIR DE QUADROS**
**(Coordenador(a))**

**Endereço:** Avenida Roraima, 1000 - Prédio da Reitoria - 7º andar - sala 763 - Sala Comitê de Ética - 97105-900 - Santa
**Bairro:** Camobi **CEP:** 97.105-970
**UF:** RS **Município:** SANTA MARIA
**Telefone:** (55)3220-9362 **E-mail:** cep.ufsm@gmail.com

# ANEXO B – NORMAS PARA PUBLICAÇÃO NO PERIÓDICO CLINICAL ORAL IMPLANTS RESEARCH

https://onlinelibrary.wiley.com/page/journal/16000501/homepage/forauthors.html#aimsandscope

**Author Guidelines**

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**Sections**



## 1. SUBMISSION

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## 2. AIMS AND SCOPE

*Clinical Oral Implants Research* conveys scientific progress in the field of implant dentistry and its related areas to clinicians, teachers and researchers concerned with the application of this information for the benefit of patients in need of oral implants. The journal addresses itself to clinicians, general practitioners, periodontists, oral and maxillofacial surgeons and prosthodontists, as well as to teachers, academicians and scholars involved in the education of professionals and in the scientific promotion of the field of implant dentistry.

## 3. MANUSCRIPT CATEGORIES AND REQUIREMENTS

- **Original research articles** of high scientific merit in the field of surgical and prosthetic aspects of clinical oral implant dentistry including material sciences, physiology of wound healing, prevention and treatment of pathologic processes jeopardizing the longevity of implants, clinical trials on implant systems, stomatognathic physiology related to oral implants, new developments in therapeutic concepts and prosthetic rehabilitation.
  In general, Clinical Oral Implants Research accepts in vitro studies for review only when there is an in

vivo component to the study. Clinical Oral Implants Research encourages complete reporting of all data in one manuscript as opposed to reporting data (for example clinical and radiographic data) in multiple manuscripts.

- **Review articles** by experts on new developments in basic sciences related to implant dentistry and clinically applied concepts. Reviews are by invitation only from the Editor-in-Chief.
- **Perspective articles** on topical areas related to implant dentistry and clinically applied concepts by invitation only from the Editor-in-Chief.
- **Case reports** and case series, but only if they provide or document new fundamental knowledge and if they use language understandable to the clinician.
- **Novel developments** if they provide a technical novelty for any implant system
- **Short communications** of important research findings in a concise format and for rapid publication.
- **Proceedings of international meetings** may also be considered for publication at the discretion of the Editor-in-Chief.

**4. PREPARING THE SUBMISSION**

**Clinical Oral Implants Research now offers Free Format submission for a simplified and streamlined submission process.**

Before you submit, you will need:

- Your manuscript: this should be an editable file including text, figures, and tables, or separate files – whichever you prefer. All required sections should be contained in your manuscript, including abstract, introduction, methods, results, and conclusions. Figures and tables should have legends. Figures should be uploaded in the highest resolution possible. References may be submitted in any style or format, as long as it is consistent throughout the manuscript. Supporting information should be submitted in separate files. If the manuscript, figures or tables are difficult for you to read, they will also be difficult for the editors and reviewers, and the editorial office will send it back to you for revision. Your manuscript may also be sent back to you for revision if the quality of English language is poor.
- An ORCID ID, freely available at https://orcid.org. *(Why is this important? Your article, if accepted and published, will be attached to your ORCID profile. Institutions and funders are increasingly requiring authors to have ORCID IDs.)*
- The title page of the manuscript, including:
    - Your co-author details, including affiliation and email address. *(Why is this important? We need to keep all co-authors informed of the outcome of the peer review process.)*
    - Statements relating to our ethics and integrity policies, which may include any of the following *(Why are these important? We need to uphold rigorous ethical standards for the research we consider for publication):*
        - data availability statement
        - funding statement
        - conflict of interest disclosure
        - ethics approval statement
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**If you are invited to revise your manuscript after peer review, the journal will also request the revised manuscript to be formatted according to journal requirements as described below.**

**Parts of the Manuscript**

The manuscript should be submitted in separate files: main text file; figures.

**Main Text File**

The text file should be presented in the following order:

i. A short informative title containing the major key words. The title should not contain abbreviations (see Wiley's **best practice SEO tips**). Trade/product names should not be included in the title;
ii. A short running title of less than 60 characters;
iii. The full names of the authors;
iv. The author's institutional affiliations where the work was conducted, with a footnote for the author's present address if different from where the work was conducted;
v. Acknowledgments;
vi. Author contributions: Please provide a statement listing the contributions made by each of the authors. Example: A.S. and K.J. conceived the ideas; K.J. and R.L.M. collected the data; R.L.M. and P.A.K. analysed the data; and A.S. and K.J. led the writing. Please refer to the journal's Authorship policy in the **Editorial Policies and Ethical Considerations section** for details on author listing eligibility;
vii. Abstract, MeSH term keywords and word count;

viii. Main text;
ix. References;
x. Tables (each table complete with title and footnotes);
xi. Figure legends;
xii. Appendices (if relevant).

Figures and supporting information should be supplied as separate files.

**Authorship**

Please refer to the journal's authorship policy the **Editorial Policies and Ethical Considerations section** for details on eligibility for author listing.

**Acknowledgments**

Contributions from anyone who does not meet the criteria for authorship should be listed, with permission from the contributor, in an Acknowledgments section. Financial and material support should also be mentioned. Thanks to anonymous reviewers are not appropriate.

**Conflict of Interest Statement**

Authors will be asked to provide a conflict of interest statement during the submission process. For details on what to include in this section, see the section 'Conflict of Interest' in the **Editorial Policies and Ethical Considerations section** below. Submitting authors should ensure they liaise with all co-authors to confirm agreement with the final statement.

**Abstract**

Abstracts should not to exceed 250 words. This should be structured into: objectives, material and methods, results, conclusions, and no other information. Trade/product names must not be included in the abstract.

**Keywords**

Please provide 3-8 keywords. Keywords should be taken from those recommended by the US National Library of Medicine's Medical Subject Headings (MeSH) browser list at **www.nlm.nih.gov/mesh**.

**Main Text of Original Research Articles**

The main text should include Introduction, Material and Methods, Results and Discussion.

- **Introduction:** Summarise the rationale and purpose of the study, giving only strictly pertinent references. Do not review existing literature extensively. State clearly the working hypothesis.
- **Material and Methods:** Material and methods should be presented in sufficient detail to allow confirmation of the observations. Published methods should be referenced and discussed only briefly, unless modifications have been made. Indicate the statistical methods used, if applicable. Clinical trial registration number and name of the trial register should be included in the Materials and Methods at the submission stage.
  Authors who have completed the ARRIVE guidelines, STROBE or CONSORT checklist should include as the last sentence in the Methods section a sentence stating compliance with the appropriate guidelines/checklist.
- **Results:** Present your results in a logical sequence in the text, tables, and illustrations. Do not repeat in the text all data in the tables and illustrations. The important observations should be emphasised.
- **Discussion:** Summarise the findings without repeating in detail the data given in the Results section. Relate your observations to other relevant studies and point out the implications of the findings and their limitations. Cite other relevant studies.

**Main Text of Short Communications**

Short communications are limited to two printed pages including illustrations and references and need not follow the usual division into material and methods, etc., but should have an abstract.

**References**

**APA** – American Psychological Association

References should be prepared according to the Publication Manual of the American Psychological Association (6th edition). This means in text citations should follow the author-date method whereby the author's last name and the year of publication for the source should appear in the text, for example, (Jones, 1998). The complete reference list should appear alphabetically by name at the end of the paper.

A sample of the most common entries in reference lists appears below. Please note that a DOI should be provided for all references where available. For more information about APA referencing style, please refer to

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***Journal article***

Beers, S. R. , & De Bellis, M. D. (2002). Neuropsychological function in children with maltreatment-related posttraumatic stress disorder. The American Journal of Psychiatry, 159, 483–486. doi:**10.1176/appi.ajp.159.3.483**

***Book edition***

Bradley-Johnson, S. (1994). Psychoeducational assessment of students who are visually impaired or blind: Infancy through high school (2nd ed.). Austin, TX: Pro-ed.

***Internet Document***

Norton, R. (2006, November 4). How to train a cat to operate a light switch [Video file]. Retrieved from **http://www.youtube.com/watch?v=Vja83KLQXZs**

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Example:

1st in-text citation: (Gilley, Johnson, Witchell, 2015)

2nd and any other subsequent citations: (Gilley, et al.)

If your source has six or more authors, only include the first author's name in the first citation and follow it with et al. Include the year the source was published and the page numbers (if it is a direct quote).

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