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Comparison between Bone Graft Surgery and Computer-Aided Implant Surgery for Implant Placement in the Maxillary Posterior Area: A Two-Year Randomized Prospective Trial

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Abstract

Objective: The aim of this study is to compare between two implant placement techniques, that is, Bone Graft Surgery (BGS) prior to freehand implant placement and Computer-Aided Implant Surgery (CAIS), in patients with maxillary atrophy.

Materials and methods: Patients with partial edentulous in the posterior atrophic maxilla were selected for a randomized controlled clinical trial, which was designed to compare implants in the posterior partially edentulous maxilla. The patients were randomized into two groups: one group planned to receive a bone graft prior to freehand implant placement and the other group planned to undergo computer-aided implant surgery. A total of 30 participants were assigned to each group. The two treatment arms were compared at a threshold of 5%, and a clinical evaluation was performed two years after the delivery of definitive cement-retained prostheses. Patient satisfaction was measured using the Verbal Rating Scale.

Results: Clinical evaluation two years after the delivery of a definitive cement-retained prostheses proved the presence of peri-implantitis (p=1.00), patient satisfaction (p=0.938), and criteria of success (pain around the implants,

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p=0.490; stability of all implants; infectious signs over the two-year period, p=1.00; abnormal radiographic findings observed around implants, p=0.490; bone craters, p=0.023; loss of one of the implants over the two-year period, p=0.490; and presence of keratinized gingiva, p=0.235). Moreover, no correlation was observed among plaque accumulation around implants, periodontal probing, and the technique of surgery used.

Conclusion: At the follow-up evaluation two years ± 5 months after implant loading, both groups demonstrated nearly equal clinical results in terms of implant placement, except for saucerization, in which a higher proportion was obtained with Bone Graft Surgery than with computer-aided implant surgery.

Introduction

With regard to the rehabilitation of lost teeth, dental implants have expanded treatment options for prosthodontists and their patients [1]. An adequate bone thickness is essential for osseointegration and subsequent functional load bearing [2]. However, it is clinically challenging to insert implants into the posterior maxilla in case of extensive maxillary sinus pneumatization [3,4]. Therefore, reducing the size of this sinus cavity partially or completely using a surgical procedure [5] to increase the size of the maxillary bone using a graft is a means by which to overcome this obstacle. This procedure is called maxillary sinus augmentation or maxillary sinus floor elevation [6].

Simultaneous sinus floor elevation and implant placement should only be performed if the bone quality and quantity are sufficient to allow the implant to have favorable primary stability [7]. This means that if less than a 4-5 mm vertical bone height is available, the implant surgery should be performed at a second stage, normally at least four months after performing maxillary sinus elevation with a bone graft [8]. According to the Glossary of Oral and Maxillofacial Implants, a maxillary sinus floor graft is a graft used to augment the vertical height in the maxillary sinus for implant placement [9].

In digital dentistry, an increasing number of digital imaging technologies have become available for accurate preoperative planning of implant placement. These technologies have also become more precise, reaching an accuracy between 106 and 760 µm in cone beam computed tomography (CBCT) [10].

Computer-Aided Implant Surgery (CAIS) is used not only in accurate planning for optimal positioning of implants via 3D imaging, but also in the fabrication of surgical guides based on preplanned positioning for accurate placement of implants [11].

Patient-Reported Outcome Measures (PROMs) are the tools or instruments used to assess the patients' perspectives of their health, quality of life, or functional status associated with health care or treatment. PROMs are directly reported by the patients, usually in the form of a questionnaire [12].

Generally, PROMs are applied in research and/or clinical practice to ensure high-quality clinical care [13]. However, only a few studies using PROMs have investigated CAIS [13], and the studies using Proms have shown that CAIS may offer a beneficial treatment option compared to conventional implant surgery in edentulous cases.

This study was performed to compare the clinical and patient-reported outcomes between two implant placement techniques, that is, Bone Graft Surgery (BGS) and CAIS, to overcome maxillary alveolar bone deficiency in cases of maxillary atrophy. The first article of this study discusses the patient-reported outcomes of surgical interventions and evaluations one year after implant loading [14]. This article also discusses and compares the results of the clinical examination two years after implant loading.

Methods

Study design and inclusion/exclusion criteria

This study was a prospective, randomized clinical trial designed as a parallel group. It was part of a five-year study called SINIMAGE, which involved a total of 60 participants, 30 of whom have undergone BGS and 30 have undergone CAIS. All candidate participants had free posterior maxillary, had significant maxillary sinus bone resorption, and required implant placement.

This project was supported by Hospices Cavils de Lyon in the name of SINIMAGE (Ref. HCL: 2008.514/15). This study followed the principles of the Declaration of Helsinki and was approved by a local ethics committee (CPP 08/095, Ref. A 08-230; December 9, 2008).

All patients provided written consent to participate in the SINIMAGE study after being informed of the objectives and details of the study.

To become enrolled in the trial, each patient had to fulfill all of the following inclusion criteria. Patients with any of the following exclusion criteria were excluded from the study.

Inclusion criteria

- Being 18 years of age or older.
- Having a sinus bone graft that requires implant placement.
- Being eligible for CAIS for implant placement, depending on scanner examination.
- Having edentulous posterior maxilla without extraction in the past three months.
- Having an occlusion that allows for non-contact lateral movements of the prosthesis.
- Having an antagonistic arcade with natural teeth or implants.
- Being a nonsmoker or active smoker or having stopped smoking for at least three months.

Exclusion criteria

- Being unable to understand the treatment information for linguistic, legal, or psychological reasons.
- Being pregnant.
- Being at a high risk of infective endocarditis or Creutzfeldt–Jakob disease.
- Having acquired immunodeficiency syndrome.
- Having a malignant disease or a history of radiation therapy at a specific region.

- Having severe hemopathy, autoimmune disease, osteoporosis, rheumatoid arthritis, chronic renal failure, poorly controlled diabetes, hemophilia, or psychiatric illness or needing an organ transplant.

- Taking high doses of corticosteroids orantimitotic or immunosuppressive medications.

- Being a drug addict.

- Being a smoker who is within a three-month restriction period.

- Being a prisoner.

Bone Graft Surgery was confirmed to be indicated by assessing a panoramic X-ray and then double-checked by assessing a CBCT image (sub sinus alveolar bone height< 5 mm), whereas Computer-Aided Implant Surgery was confirmed to be indicated using the EasyGuide™ dental implant planning software (Keystone-Dental, Inc, Burlington, MA, USA); Figure 1. With this software, measurements of each CBCT image showed that the remaining alveolar bone was of adequate dimensions for implant, with the height and width of the residual vertical posterior bone of the sinus side being more than 10 mm × 5 mm.

To select patients who are eligible for treatment with either BGS or CAIS, the screening program for all patients included the following steps:

- Panoramic X-rays were performed using a Planmeca ProMax® 2D (Planmeca Oy, Asentajankatu, Helsinki, Finland) imaging device at the Department of Oral Surgery, University Claude Bernard Lyon (UCBL).

- Two expert surgeons from the Center of Dental Care Education and Research, UCBL, France, assessed these panoramic X-rays to confirm that the cases are eligible for a sinus graft.

- Surgical guides were fabricated from wax models by a laboratory affiliated to the center.

- CBCT imaging was performed at the Imaging Department of Hospital Édouard Herriot in Lyon, France.

- Surgeons from the center assessed the 3D images to confirm the eligibility for CAIS.

- A clinical examination was performed to evaluate the patient inclusion and exclusion criteria.

All 60 patients fulfilled the determined criteria and were randomly assigned, using sealed envelopes, to two study treatment groups:

1. BGS prior to freehand implant placement for 30 patients.

2. CAIS for 30 patients.

According to the study protocol, the inclusion period in this study was two years. The first surgical treatment took place on September 29, 2009, for a patient in the BGS group, whereas the first surgical treatment in the CAIS group took place on October 6, 2009. The first loading of a definitive implant prosthesis took place on August 7, 2010, for a patient in the CAIS group, whereas the last loading took place on March 3, 2015, for a patient in the BGS group. The last examination was performed according to the SINIMAGE protocol five years after implant loading with fixed prostheses (Figure 2).

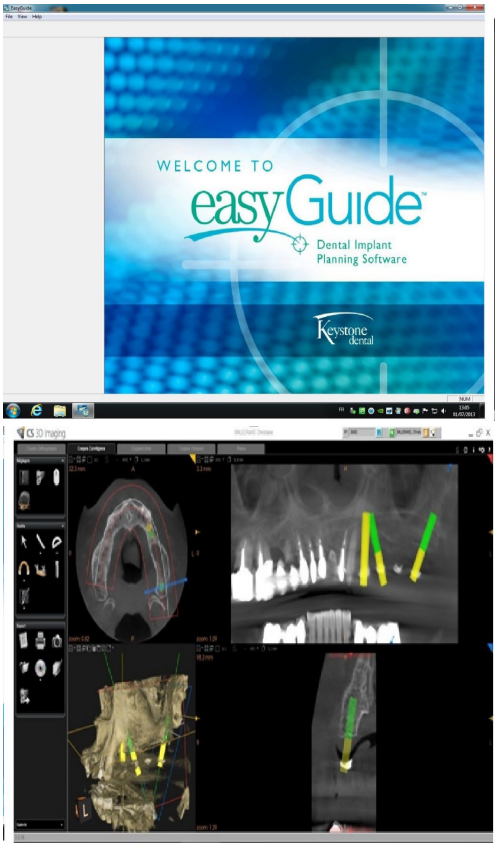


Figure 1: EasyGuide™ dental implant planning software.

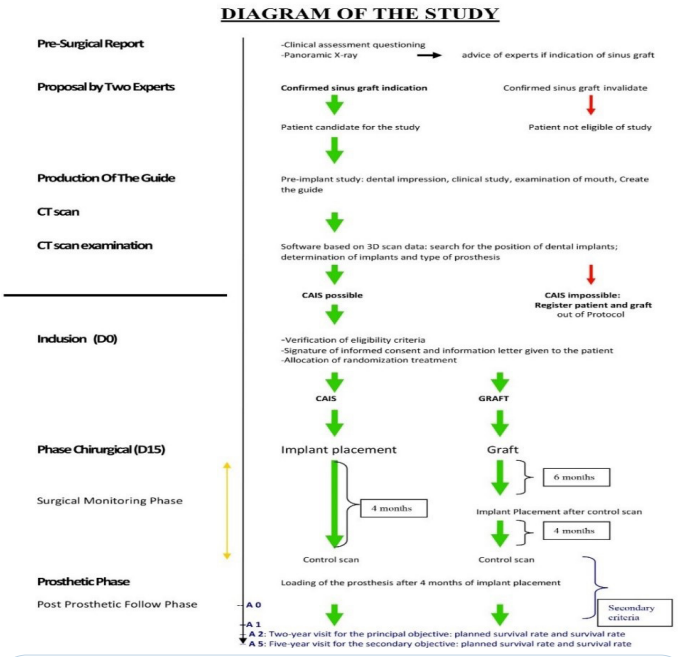


Figure 2: Protocol of SINIMAGE.

Surgical procedure

Patients in each group were accorded a unified treatment approach as defined in the Case Report Form (CRF) created for each group. In these CRFs, treatment details and patient-reported outcomes were documented.

- Either a XiVE®implant (Dentsply Sirona Inc., Charlotte, NC, USA) or an Ankylos® implant (Dentsply Sirona Inc.) was placed at the planned locations, ranging in length from 8 to 13 mm and in diameter from 3.5 to 5.0 mm.

- An internal connection PrimaConnex® Tapered Implant (Keystone Dental, Inc.) was used to join the implant to the pros-

thesis. An abutment was placed only after confirming the presence of osseointegration in the bone surrounding the dental implants using intraoral X-ray imaging.

- Cement-retained definitive implant prostheses were used in all implants.

BGS Group. A total of 30 patients were planned for treatment using the two-stage technique of BGS (Figure 3).

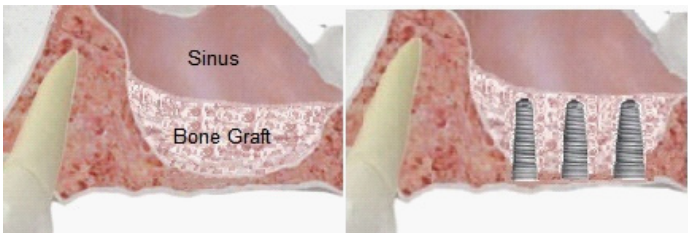


Figure 3: Bone graft and bone integration of sinus floor on implant placement.

First stage: Bone grafting was surgically performed to lift the Schneiderian membrane, and then it was strictly secured. A window was created on the lateral sinus wall to allow the placement of the PHOENIX allograft bone (TBF GénieTissulaire, Mions, France) under the sinus membrane. A DynaMatrix® membrane (Keystone Keystone Dental, Inc.) was used to provide support for tissue regeneration, after which flap surgery was performed to obtain tight closure.

Second stage: Bone integration usually occurs six to eight months after implant placement. A sinus scan was performed to confirm bone integration prior to the second stage. After anesthesia, the pilot hole in the maxillary crest was drilled by the surgeon. Progressive drilling is usually performed using drills of several sizes until achieving the required diameter to insert the implant. XiVE® and Ankylos® implants (Dentsply Sirona Inc.) were used according to the study protocol. Finally, the surgeon placed healing screws and then performed flap surgery to achieve tight closure. An internal connection was inserted into the implant to join the implant to the final prosthesis.

CAIS Group. A total of 30 patients were planned for treatment using CAIS (Figure 4).

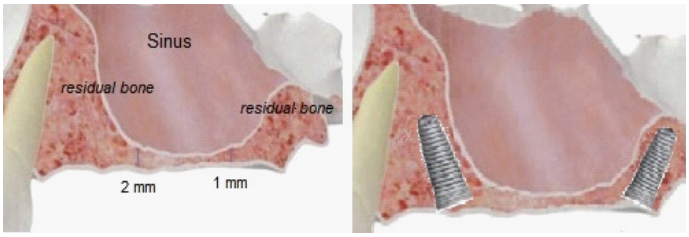


Figure 4: Benefit from the residual maxillary bone on implant placement by a surgical.

Prior to the surgery, 3D scanning was used to attach the template to a resin cube (a fiducial marker). Implant positioning was determined using the EasyGuide™ planning software (Keystone Dental Inc.). Following the surgical guide created for transferring the planned implant to the surgical site, a digitally controlled drilling machine was used to make holes in the template and plaster cast. This method of implant transfer is known for its high accuracy [15].

After anesthesia, the drilled surgical guide was placed on the maxillary bone and fixed in the mouth. The surgeon then inserted the drill sleeves into surgical guide holes to create a cavity at the top of the residual bone crest. This small cavity provided an entrance for the pilot osteotomy to use drills of several sizes to establish a position for implant insertion. XiVE® and Ankylos® implants (Dentsply Sirona Inc.) were used according to the study protocol.

Finally, the surgeon placed healing screws and performed flap surgery to achieve tight closure. Then, an internal connection was inserted into the implant.

Follow-up evaluation two years after implant loading

All patients underwent a clinical examination 24±5 months after implant loading with fixed prostheses. The definition of success rate used in this study is the one proposed by Albrektsson [16]. The criteria of success for implant placement were relatively easy to apply:

(1) The implant is fixed and immobile.

(2) X-ray shows no radiolucent area around the implant.

(3) Vertical bone loss in the first year after implant loading allows for 0.1–1.5 mm bone loss [17-19] in contrast to 0.2 mm in the following years after dental implant [20].

(4) The implant is free of and/or shows no irreversible signs or symptoms, such as pain, infection, and paresthesia.

According to the study protocol in the CRFs, several points were identified in the examination:

• Patient satisfaction was evaluated using the Verbal Rating Scale (VRS), which asks the patients to choose one of several response categories [21] for satisfaction. These response categories have been developed to include all degrees of patient satisfaction, ranging from *Not satisfied with treatment* to *Completely satisfied with treatment*. Patients are asked to express their degree of satisfaction with the whole treatment procedure on a four-point scale (*Not at all satisfied*, *A little satisfied*, *Satisfied*, and *Very satisfied*).

• The criteria of success, as defined by the study protocol, revealed an inflammatory lesion of the peri-implant mucositis. Peri-implantitis affected the implants as a result of complex flora, resulting in a condition close to active periodontitis, which also includes loss of supporting bone [22].

- Peri-implantitis.
- Pain around one of the implants.
- Stability of implants.
- Signs of infection around one of the implants, such as pain, infection, and paresthesia.
- Abnormal radiographic implant findings.
- Occurrence of adverse events.
- Radiological evaluation showing loss of marginal bone or saucerization.
- Loss of one of the implants.
- Presence of keratinized gingiva.
- Plaque accumulation around the implants.
- Plaque accumulation was evaluated according to the

study protocol as follows: no plaque detected, plaque visible to the naked eye, and plaque only recognized by running a probe across the cervical margin of the tooth and abundant plaques.

- Periodontal probing.

- Periodontal stability status and sub gingival bacterial deposits were inspected during the clinical examination, since the severity and progression of periodontitis are related to biofilm formation, host susceptibility, and modification of environmental and behavioral factors [23]. The study protocol also included an evaluation of the periodontal status via periodontal probing as follows: bleeding on probing, red line bleeding on the marginal gingival, visible bleeding points, and abundant bleeding.

Statistical analysis

In this study, qualitative variables were evaluated using a percent value and crosstab statistics to allow for examining the relationships between these variables in the two groups of treatment using the *p*-value (chi-squared test, Fisher's exact test).

Normality tests revealed that none of the quantitative variables in the study showed a normal distribution. The variables nearest to real representation among these were median values within the Interquartile Range (IQR). The Mann–Whitney *U* test was used to compare the differences between the two groups using the *p*-value.

A *p*-value less than 0.05 was considered statistically significant. According to the null hypothesis, the technique of implant placement has no effect on the clinical examinations two years after implant loading.

Results

Bone graft surgery

A total of 30 patients in the BGS group received implants after successful sinus grafting (Figure 5), and 25 patients underwent a control examination two years after receiving definitive fixed implant prosthesis. The reasons for dropouts were as follows:

- One patient dropped out of the study because of depression.

- Two patients asked to drop out of the study for personal reasons.

- One patient decided to use a removable prosthesis.

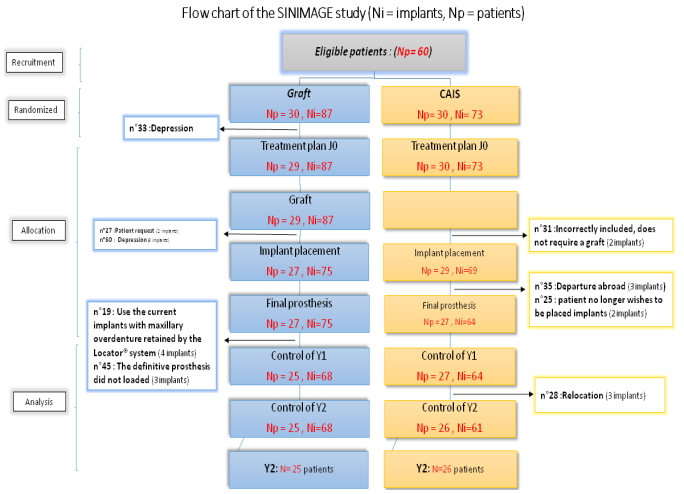
- One patient did not receive the definitive fixed implant prosthesis (lost to follow-up).

Computer-aided implant surgery

A total of 30 patients in the CAIS group received implants using the surgical guide created by 3D planning software as well as 3D imaging by CBCT (Figure 5), and 26 patients underwent a control examination after two years to place the final prostheses on the implants. The reasons for dropouts were as follows:

- One patient decided against new implant placement.

- Two patients moved to another city.



Np: number of patients; *Ni*: number of implants.

Figure 5: Flow chart of SINIMAGE.

Population characteristics

No significant difference was found between the two surgical techniques in terms of the age and gender of the study participants (Table 1). A total of 19 women (63.3%) were included in the BGS group, whereas 18 women (60.0%) were included in the CAIS group (p=0.791). The age of the participants was μ=56.7±9.16 in the BGS group with a range of 35–73 years versus μ=59.5±8.96 in the CAIS group with a range of 30–69 years (p=0.809).

Follow-up evaluation after two years

All patients of the two groups were clinically examined two years after implant loading.

Success rate

The success rate is defined as the number of implants meeting the success criteria/number of implants placed. Two patients from the BGS group were found to have failed implants; thus, the success rate of BGS was 94.11%. The first patient had an infection around the implant (three implants were placed for this patient), and dental plaque on the cervical collar was visible to the naked eye, accompanied by gingival bleeding. The second patient had a radiolucent area around the implant detected on X-ray (one implant was placed for this patient), along with abundant dental plaque without gingival bleeding. In the CAIS group, one patient had a failed implant, resulting in a success rate of implant placement of 96.72%. This patient demonstrated signs of infection in a small mesial periodontal pocket.

Patient satisfaction

Patient satisfaction was evaluated using the VRS (Table 2).

All patients pointed out that they were a "Little Satisfied" or "Very Satisfied," and none of them expressed being "Satisfied" or "Not at all Satisfied." The frequency of using the term "Very Satisfied" was nearly equal in the two types of surgery, with 19 patients (76.0%) in the BGS group versus 20 patients (76.9%) in the CAIS group. Some patients also expressed being "A Little Satisfied," with a total of six patients in the BGS group (24.0%) and six patients in the CAIS group (23.1%).

According to a chi-squared test for independence, no significant difference was found in terms of the frequency of using the term "Very Satisfied" for patients in the two groups (n=51, p=0.938).

Criteria of success

The criteria for successful treatment have been identified in the CRFs by clinically examining the patients (which has been defined by the study protocol), (Table 3).

According to a Fisher's exact test for independence, no significant differences were found across the criteria for successful treatment for both surgical techniques in the CRFs. An exception was marginal bone or saucerization, in which there was a relationship between the disclosure of an osseous crater and the surgical technique at a threshold of 5%, a significant difference for the bone saucerization proportion for both types of surgery. The proportion of saucerization was found to be higher in the BGS group than in the CAIS group, with eight patients (32.0%) in the BGS group compared to one patient (4.0%) in the CAIS group (one patient in the CAIS group did not undergo a radiological test to evaluate saucerization).

One patient in each group had peri-implantitis, resulting in an approximately equal incidence in the two groups: 4.0% for BGS group and 3.8% for the CAIS group. Regarding pain in the area of one of the implants, one case (4.0%) has been reported in the BGS group, whereas no cases (0.00%) have been reported in the CAIS group.

Equal stability of implants was also observed in the two treatment groups. All patients had stable implants: 25 patients (100%) in the BGS group and 26 patients (100%) in the CAIS group.

Clinical examinations were performed to check all the patients for signs of infection around the implants. The same percentages of patients were found to exhibit signs of infection in both groups: 4.0% (one patient in each of the two groups). In the CAIS group, no abnormal images were found, and none of the patients experienced an implant loss, whereas in the BGS group, one patient (4.0%) had an abnormal image and experienced an implant loss.

All patients in the CAIS group were found to have keratinized gingiva versus 23 patients (92.2%) in the BGS group. Moreover, one patient from each group experienced an adverse event: one patient (4.0%) from the BGS group and one patient (3.8%) from the CAIS group.

Plaque accumulation around implants

No relationship was found between plaque accumulation around the implants and the technique of surgery used, at a threshold of 5 %, (Table 4). It should be noted that the number of patients with no plaque who underwent CAIS (20 patients, 76.9%) was higher than the number of patients who underwent BGS (17 patients, 68.0%). The groups were nearly equal in terms of the amount of plaque discovered by running a probe across the cervical margin of the tooth: three patients (12.0%) in the BGS group and four patients (15.4%) in the CAIS group. Moreover, four patients (16.0%) in the BGS group had plaque visible to the naked eye compared to one patient (3.8%) in the CAIS group. None of the patients in the CAIS group had abundant plaque, whereas one patient (4.0%) in the BGS group had abundant plaque.

Periodontal probing

Clinical examination has shown that periodontal probing is affected by the probe depth into the gingival sulcus. Four periodontal probe terms were considered within the CRFs: No bleeding, visible bleeding points, red line bleeding on the marginal gingiva, and abundant bleeding. No relationship was found between the two surgical techniques of implant placement and periodontal probing at a threshold of 5%, (Table 5).

In the BGS group, one patient had visible bleeding points, another patient had visible bleeding points in addition to a marginal bleeding line, and a third patient had visible bleeding points in addition to a marginal bleeding line and abundant bleeding. In the CAIS group, 24 patients (92.3%) exhibited bleeding upon probing, compared to 22 patients (88.0%) in the BGS group. The numbers of patients who had visible bleeding points were nearly equal in both groups: Three patients (12.0%) in the BGS group versus two patients (7.7%) in the CAIS group. In the CAIS group, none of the patients exhibited red line bleeding in the marginal gingiva or abundant bleeding, whereas in the BGS group, two patients (8.0%) exhibited red line bleeding and one patient (4.0%) experienced abundant bleeding.

Table 1: Population Characteristics.

Population Characteristics			
	BGS (n=30)	**CAD (n=30)**	**P-Value**
Sex	19 women (63.3%)	18 women (60.0%)	0.791
Age	56.7±9.16 years	59.5±8.96 years	0.809

Table 2: Patient satisfaction.

Satisfy Patients by (VRS) [effective (percentage)]		
	BGS (n=25)	**CAIS (n=26)**
Not at all satisfied	0	0
Little satisfied	6 patients (24.0%)	6 patients (23.1%)
Satisfied	0	0
Very satisfied	19 patients (76.0%)	20 patients (76.9%)

Table 3: Evaluation of the success criteria.

Criteria of the success [effective (percentage)].			
	BGS (n=25)	**CAIS (n=26)**	**P-Value**
Very satisfied	19 patients (76.0%)	20 patients (76.9%)	
Little satisfied	6 patients (24.0%)	6 patients (23.1%)	
Peri- implantitis	1 patient (4.0%)	1 patient (3.8%)	1.00
Pain around one of the implants	1 patient (4.0%)	(0.00%)	0.490
Stability of implants	25 patients (100%)	26 patients (100%)	

Infectious signs around one of the implants	1 patient (4.0%)	1 patients (3.8%)	1.00
Abnormal radiographic imaging	1 patient (4.0%)	(0.00%)	0.490
Occurrence of undesirable events	1 patient (4.0%)	1 patient (3.8%)	1,00
Radiology evaluation of saucerization	8 patients (32.0%)	1 patient (4.0%)	0.023
Loss of one of the implants	1 patient (4.0%)	(0.00%)	0.490
Presence of keratinized gingiva	23 patients (92.0%)	26 patients (100%)	0.235

Table 4: Plaque accumulation around implants.

Plaque Accumulation AroundImplants [effective (percentage)]			
	BGS (n=25)	**CAIS (n=26)**	**P-Value**
No plaque	17 patients (68.0%)	20 patients (76.9%)	0.475
Plaque at the cervical margin	3 patients (12.0%)	4 patients (15.4%)	1.00
Plaque visible to the naked eye	4 patients (16.0%)	1 patient (3.8%)	0.191
Abundant plaque	1 patient (4.0%)	(0.00%)	0.490

Table 5: Periodontal Probing.

Periodontal Probing [effective (percentage)]			
	BGS (n=25)	**CAIS (n=26)**	**P-Value**
No bleeding	22 patients (88.0%)	24 patients (92.3%)	0.668
Visible bleeding points	3 patients (12.0%)	2 patients (7.7%)	0.668
Red line bleeding on the marginal gingiva	2 patients (8.0%)	(0.00%)	0.235
Abundant bleeding	1 patient (4.0%)	(0.00%)	0.490

Discussion

This study is a single-center trial whose aim is to compare two techniques of implant placement for cases of atrophic maxillary sinus. The protocols of both surgical techniques allowed for the placement of implants according to CRFs in two groups. Clinical investigations utilizing PROMs and randomized controlled trials in literature reviews of dental implant placement have not clarified the economic effects in terms of treatment cost and time efficiency. Therefore, it is necessary to address the efficacy of CAIS [24] in dental implant placement surgeries.

With regard to patient-reported outcomes, when BGS and CAIS were compared, no statistically significant differences were found between the two surgical techniques upon clinical examination after one year of implant loading [14].

Clinical examination was performed two years after implant loading. The numbers of patients who dropped out were found to be close in both groups: five patients from the BGS group and four patients from the CAIS group.

Peri-implantitis was not detected in49 patients (96.1%) in the two groups two years after implant loading with a fixed prosthesis. In addition, the majority of the patients were satisfied, as evidenced by the recorded success rate and reliability of both treatments. Indeed, most patients were satisfied with the treatment as registered via the VRS. However, in the CAIS group, only one patient experienced peri-implantitis, which was diagnosed during the clinical examination two years after implant loading.

Generally, the accuracy of computer technology applications and their precision in surgical implant dentistry have been demonstrated in a number of research studies. Computer-aided implant placement with treatment planning has a mean accuracy of approximately 1.09 mm at the entry point and 1.51 mm at the implant apex [25].

Maxillary sinus grafting has been performed for more than 30 years and has been routinely considered as a predictable reliable procedure [26]. A low rate of postoperative complications has been observed, and the success rate of implant placement confirms the reliability of bone grafting in the placement of dental implants [26].

The results of the clinical examinations of the criteria of success were recorded in CRFs. The study protocol defined the criteria of success for implants in terms of the following: Presence or absence of peri-implantitis, stability, signs of infection, pain, abnormal radiographic imaging of implants, occurrence of adverse events, saucerization of bone, loss of one of the implants, and presence or absence of keratinized gingiva. The results of the two groups were nearly similar for all the criteria of success, except for one at the two-year post implantation point. The reliability of both surgical techniques of implant placement in this study is also shown by the results of the clinical examination. All the results except for one did not show statistically significant differences.

Two years after implant loading, clinical examination demonstrated the stability of all implants except for one in a patient from the BGS group. None of the Patients from the CAIS group experienced any pain in the area of the implants. One patient within each group showed signs of infection in the area of one of the implants. Radiological examination of the implants demonstrated transparency in only one patient and the presence of keratinized gingiva in two patients from the BGS group.

Clinical examination for the accumulation of plaque included four categories according to the CRFs of the study: No plaque, plaque at the cervical margin, plaque visible to the naked eye, and abundant plaque. Upon clinical examination for plaque accumulation, the most common result was no plaque around the implants: 68.0% of the patients in the BGS group versus 76.9% of the patients in the CAIS group. The proportions of patients who experienced plaque accumulation in the BGS group were as follows: plaque at the cervical margin (12.0%), plaque visible to the naked eye (16.0%), and abundant plaque (4.0%). In contrast, the proportions of patients who experienced plaque accumulation in the CAIS group were as follows: plaque at the cervical margin (15.4%), plaque visible to the naked eye (3.8%), and abundant plaque (0%). Thus, it can be concluded that the plaque accumulation results were better in the CAIS group.

The study protocol defined four categories of periodontal probing: no bleeding, red line bleeding on the marginal gingiva, visible bleeding points, and abundant bleeding. No bleeding on probing was found in 46 patients (90.2%): 88.0% in the BGS group versus 92.3% in the CAIS group. Visible bleeding points were found in two patients from the CAIS group (7.7%) and in one patient from the BGS group. Two patients from the CAIS group were also found to have visible bleeding points, whereas three patients from the BGS group were found to have multiple forms of bleeding upon periodontal probing. Comparison between the results showed a similarity upon periodontal probing with some preference for CAIS. Clinical examination via periodontal probing showed that most of the patients in the study exhibited no bleeding, thanks to the reliability of the two surgical techniques of implant placement and the low rate of complications in both groups [14].

A radiological evaluation aimed at revealing the loss of marginal bone or saucerization demonstrated statistically significant differences, providing evidence that there is a correlation between the saucerization of bone two years after prosthesis placement and the two surgical techniques of implant placement. This result is in line with that of a that found elevation in the states of surgical complications associated with implants placed in the bone augmented of sinus floor in comparison to implants placed in the native bone [27].

Smith and Zarb [28] suggested that one of the criteria for implant success is the loss of less than 0.2 mm of marginal bone per year after the first year. One patient (4.0%) from the CAIS group was found to exhibit bone saucerization compared to eight patients (32.0%) in the BGS group. This may be due to a difference in the bone quality in both types of surgery for implant placement: Bone grafting (bone remodeling) in the BGS group and residual alveolar bone (original bone) in the CAIS group.

These results were expected since CAIS allows more accurate surgical implant placement, which minimizes errors and complications. CAIS also reduces the frequency of complications [29] and allows eliminating manual errors in implant placement and more requirements of planning a prosthetics [30]. Computer-assisted surgery with preoperative surgical planning, based on 3D images to evaluate the bone morphology, allows surgeons to perform accurate virtual surgeries [31].

Conclusion

In this study, it was found that the results of the clinical examination performed two years after implant loading in patients from both groups were nearly equal, except for bone saucerization. The two implant placement techniques did not show statistically significant differences, except for bone saucerization. Such exception, bone saucerization, had a higher proportion in the BGS group than in the CAIS group, thus evidencing the relationship between the appearance of an osseous crater and the surgical technique performed for implant placement.

Conflict of interest

The authors declare no conflict of interest.

References

1. Rich B, Goldstein GR. New paradigms in prosthodontic treatment planning: A literature review. J Prosthet Dent. 2002; 88: 208–214.
2. Nasr S, Slot DE, Bahaa S, Dörfer CE, Fawzy El-Sayed KM. Dental implants combined with sinus augmentation: What is the merit of bone grafting?. A systematic review. J Cranio-Maxillofac Surg Off Publ Eur Assoc Cranio-Maxillo-fac Surg. 2016; 44: 1607–1617.
3. Wehrbein H, Diedrich P. [Progressive pneumatization of the basal maxillary sinus after extraction and space closure]. Fortschr Kieferorthop. 1992; 53: 77–83.
4. Sharan A, Madjar D. Maxillary sinus pneumatization following extractions: A radiographic study. Int J Oral Maxillofac Implants 2008; 23: 48–56.
5. Chanavaz M. Maxillary sinus: Anatomy, physiology, surgery, and bone grafting related to implantology-eleven years of surgical experience (1979-1990). J Oral Implantol. 1990; 16: 199–209.
6. Laney WR. Glossary of Oral and Maxillofacial Implants. Int J Oral Maxillofac Implants 2017; 32: Gi-G200.
7. Cha H-S, Kim A, Nowzari H, Chang H-S, Ahn K-M. Simultaneous sinus lift and implant installation: prospective study of consecutive two hundred seventeen sinus lift and four hundred sixty-two implants. Clin Implant Dent Relat Res. 2014; 16: 337–347.
8. Raghoebar GM, Vissink A, Reintsema H, Batenburg RH. Bone grafting of the floor of the maxillary sinus for the placement of endosseous implants. Br J Oral Maxillofac Surg. 1997; 35: 119–125.
9. Laney WR. Glossary of Oral and Maxillofacial Implants. Int J Oral Maxillofac Implants 2017; 32: Gi-G200.
10. Bohner L, Gamba DD, Hanisch M, Marcio BS, Tortamano Neto P, Laganá DC, Sesma N. Accuracy of digital technologies for the scanning of facial, skeletal, and intraoral tissues: A systematic review. J Prosthet Dent. 2019; 121: 246–251.
11. Wittwer G, Adeyemo WL, Wagner A, Enislidis G. Computer-guided flapless placement and immediate loading of four conical screw-type implants in the edentulous mandible. Clin Oral Implants Res. 2007; 18: 534–539.
12. Weldring T, Smith SMS. Patient-Reported Outcomes (PROs) and Patient-Reported Outcome Measures (PROMs). Health Serv Insights. 2013; 6: 61–68.

13. Allen PF. Assessment of oral health related quality of life. Health Qual Life Outcomes. 2003; 1: 40.

14. Almahrous G, David-Tchouda S, Sissoko A, Rancon N, Bosson J-L, Fortin T. Patient-Reported Outcome Measures (PROMs) for Two Implant Placement Techniques in Sinus Region (Bone Graft versus Computer-Aided Implant Surgery): A Randomized Prospective Trial. Int J Environ Res Public Health. 2020; 17.

15. Fortin T, Champleboux G, Bianchi S, Buatois H, Coudert J-L. Precision of transfer of preoperative planning for oral implants based on cone-beam CT-scan images through a robotic drilling machine. Clin Oral Implants Res. 2002; 13: 651–656.

16. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants. 1986; 1: 11–25.

17. De Smet E, Jacobs R, Gijbels F, Naert I. The accuracy and reliability of radiographic methods for the assessment of marginal bone level around oral implants. Dento Maxillo Facial Radiol. 2002; 31: 176–181.

18. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci 1998; 106: 527–551.

19. Romeo E, Lops D, Margutti E, Ghisolfi M, Chiapasco M, Vogel G. Long-term survival and success of oral implants in the treatment of full and partial arches: A 7-year prospective study with the ITI dental implant system. Int J Oral Maxillofac Implants. 2004; 19: 247–259.

20. Geraets W, Zhang L, Liu Y, Wismeijer D. Annual bone loss and success rates of dental implants based on radiographic measurements. Dentomaxillofacial Radiol. 2014; 43.

21. Friedman H, Amoo T. Rating the Rating Scales. J Mark Manag. 1999; 9: 114–123.

22. Heitz-Mayfield LJA. Peri-implant diseases: Diagnosis and risk indicators. J Clin Periodontol. 2008; 35: 292–304.

23. Page RC, Kornman KS. The pathogenesis of human periodontitis: an introduction. Periodontol. 2000; 14: 9–11.

24. Joda T, Derksen W, Wittneben JG, Kuehl S. Static computer-aided implant surgery (s-CAIS) analysing patient-reported outcome measures (PROMs), economics and surgical complications: A systematic review. Clin Oral Implants Res. 2018; 29: 359–373.

25. Schneider D, Marquardt P, Zwahlen M, Jung RE. A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. Clin Oral Implants Res. 2009; 20: 73–86.

26. Moreno Vazquez JC, Gonzalez de Rivera AS, Gil HS, Mifsut RS. Complication Rate in 200 Consecutive Sinus Lift Procedures: Guidelines for Prevention and Treatment. J Oral Maxillofac Surg. 2014; 72: 892–901.

27. Elangovan S. Dental Implant Survival in the Bone Augmented by Direct Sinus Lift Is Comparable to Implants Placed in the Native Bone. J Evid-Based Dent Pract. 2020; 20: 101410.

28. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent. 1989; 62: 567–572.

29. Park S-J, Leesungbok R, Cui T, Lee SW, Ahn S-J. Reliability of a CAD/CAM Surgical Guide for Implant Placement: An In Vitro Comparison of Surgeons' Experience Levels and Implant Sites. Int J Prosthodont. 2017; 30: 367–169.

30. Fortin T, Champleboux G, Lormée J, Coudert JL. Precise Dental Implant Placement in Bone Using Surgical Guides in Conjunction With Medical Imaging Techniques. J Oral Implantol. 2000; 26: 300–303.

31. Kanno T, Mitsugi M, Sukegawa S, Hosoe M, Furuki Y. Computer-simulated bi-directional alveolar distraction osteogenesis. Clin Oral Implants Res. 2008; 19: 1211–1218.