Endoscopic analysis of alterations in sinus floor elevation approaching the summers technique and immediate implant: a clinical trial with 10 years follow-up

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ABSTRACT

The goal of this study was to evaluate by endoscopy, possible intercurrences during the sinus floor lifting employing the Summers technique, besides verify the implants' survival rate after 10 years. Six patients (12 sinus) were included in this study. The same surgeon performed the procedures, under local anesthesia and venous sedation in the hospital. All participants underwent sinus lift and implant placement in only one procedure, as previously planned, using endoscopic analysis (Stortz®). All cases received bovine bone graft (Bio-Oss®) before the implant placement. After 10 years, the patients were recalled for follow-up. Two intercurrences (16.66%) were detected using the endoscope, one simple rupture, and another perforation with the leaking of the graft within the sinus. Both were reverted and corrected immediately. There was one implant loss (8.33%), therefore this patient did not undergo any intercurrence in transoperative, and the membrane was elevated lesser than 5 mm. The survival rate reached was 91.66%. The osteotome technique constitutes a reliable method with a long-term of 10 years presenting a high implant survival rate, suggesting an elevation up to 5.5 mm in healthy patients. The occurrences in transoperative were only detected by the endoscopic analysis which must be stimulated to guarantee more secure visibility. Otherwise, the association the atraumatic technique and endoscope was tough, increased the costs, limiting the use routinely.

Keywords: Endoscope; Maxillary sinus; Elevation; Closed technique; Sinus lifting; Summers Technique; Long-term evaluation.

INTRODUCTION

The reduction of the alveolar bone height involving the posterior region of the maxilla, under of the maxillary sinus (MS) region, represents an obstacle in the placement and success of treatment for osseointegrated implants. The pneumatization of the maxillary sinus and the resorption of the remaining bone ridge can be attributed to the possible roots of the posterior maxillary teeth (normal anatomy) within the sinus, bone resorption after extraction due to remodeling, and/or periodontal disease (BOLGER et al., 1991). Moreover, the use of a removable prosthesis can contribute aggravating the bone loss (MISCH, 2002; NKENKE et al., 2002) and the pneumatization of the MS can occur as a result of an increase in positive pressure and may be enhanced by the osteoclastic activity after tooth loss (REISER et al., 2001; TIMENGA, 2003). In order to increase the perspective to treat that challenge region, the technique of sinus elevation was firstly reported by Boyne in the 1960s. In 1980, Boyne &

James described the technique in two-stage procedures and with more than 30 years of researches have confirmed the technique successful and predictability (PJETURSSON et al., 2008; NKENKE et al., 2009; JENSEN et al., 2013; CORBELLA et al., 2015), besides presenting favorable outcomes regarding implant survival (PJETURSSON et al., 2008; ESPOSITO et al., 2010; CORBELLA et al., 2015; THOMA et al., 2015; TING et al., 2017; STARCH-JENSEN et al., 2018).

A transalveolar approach also referred to as osteotome sinus floor elevation, Summers technique, crestal approach, or still “atraumatic” elevation which was firstly suggested by Tatum (1986). In 1994 emerged a modification in this indirect sinus lift technique (SUMMERS, 1994a-c; 1995; 1996; 1998), through a greenstick fracture of the sinus floor accomplished by hand tapping using osteotomes in a vertical direction creating a ‘tent’, receiving then the graft biomaterial (PJETURSSON AND LANG, 2014). An important detail must be highlighted because the tip of the osteotome must only enter the sinus cavity after the bone grafting material was been pushed through the preparation site (PJETURSSON AND LANG, 2014). This treatment is considered an option for maxillary sinus floor augmentation (MSFA), considered lesser traumatic compared to the previous technique (FERRIGNO et al., 2006).

This closed approach is associated with reduced morbidity and post-operative discomfort and may avoid more than one procedure permitting to place the dental implant at the same surgery-time of the MSFA. Also, it normally prevents direct contact with the Schneiderian membrane (pseudostratified ciliated columnar epithelium), reducing the surgical period and the complications trans- and post-operative (PEREZ-MARTINEZ et al., 2015), but with limitations and restricted applications, because of the necessity at the minimum reminiscent of residual bone height at 4 a 5 mm (REISER et al., 2001), and with authors suggesting between 5 and 9 mm (PÉREZ-MARTINEZ et al., 2015). The survival rate for this technique has ranged between 93.5% and 100% when placed implants simultaneously with a bone graft (TOFFLER, 2004; KRENNMAIR et al., 2007) and with favorable results also obtained without bone graft (LEBLEBICIOGLU et al., 2005; NEDIR et al., 2006; LAI et al., 2008; PJETURSSON et al., 2009; SENYILMAZ AND KASABOGLU, 2011).

Nevertheless, the most common finding in the trans-operative of MSFA surgery is the perforation of the membrane (VAN DEN BERGH et al., 2000), principally because of sinus septa presence, which has a prevalence of 26.5 to 31% (ULM et al., 1995; KIM et al., 2006), and/or a small residual bone height which are the main risk factors (SCHWARZ et al., 2015; TÜKEL AND TATLI, 2018). Despite lesser invasive, the technique is uncontrollable due to accomplish a transalveolar approach which does not allow direct membrane visualization

(MISCH, 2002), may causing a micro or macrolacerations, leading possible disorders like sinusitis, infection, and graft and/or implant loss (REGEV et al., 1995; AIMETTI et al., 2001; TIMENGA, 2003). Then, a significant perforation, equal or more than 5 mm, has a probability of about 30% to occur (SHOLMI et al., 2004) in surgeries of lateral window access. A small perforation in the membrane, < 5mm, does not require any additional care, which may normally be associated with the Summers technique.

On this hand, a manner to obtain greater predictability and trying a minor chance of complications still need to be studied. Even so, there is a small number of clinical studies using the endoscope during the maxillary sinus lift (ENGELKE AND DECKWER, 1997; WILTFANG et al., 2000; NKENKE et al., 2002; SCHLEIER, 2008), and it can help to clarify a series of doubts regarding the resorted to the osteotome technique (SUMMERS, 1994a-c). Beyond, it provides a transoperative view of the inner intimacy of the MS, allowing the professional to detect complications that might lead to a failure of the inserted graft material or dental implant (TESTORI et al., 2012). A study showed in an endoscopic analysis the MS membrane can be elevated up to 5 mm without perforation (ENGELKE AND DECKWER, 1997), which can not be possible to ascertain without the endoscopy.

In a sinus lift consensus, Tonetti and Hammerle (2008) developed conclusions in short-term follow-up, based on a few trials and which were commonly underpowered. In 2016, a sinus Consensus updated and revisited the Consensus of 1996, considering common the transcrestal approach when available bone and favorable the simultaneous graft and implant placement when mechanical fixation of the implant is possible (JENSEN et al., 1996). Thus, this case series aimed to evaluate in the long-term 10 years, the implants' survival rate, using the endoscopic analysis to assess the sinus membrane's integrity trans-operatively after "atraumatic" sinus floor elevation in humans.

MATERIALS AND METHODS

This study followed the Declaration of Helsinki 1975 and was also verified the update in 2013, followed by the TREND statement, and it was previously submitted and approved by the local Ethics Research Committee (number 862005) from the Santo Amaro University (Sao Paulo, Brazil). After all the explanation and agreement of the Informed Consent, the participants were included (n=6), four females and two males, fulfilling and signing the informed consent form.

Evaluation and Surgical Procedure

The mean age of the patients was 50 years (aged 26 to 74 years old), and all procedures were performed in a hospital environment, between 2005 and 2006. As inclusion criteria, all patients needed at least one implant in maxilla posterior region in which did not have enough bone height to install the dental implant using the conventional technique, with the minimum residual bone height of 4mm, healthy or with a good systemic condition or systemically controlled, permitting the obtaining computed tomography (CBCT) and panoramic radiograph, basic blood exams such hemogram, coagulogram, glycemia, urea, creatinine, and surgical risk given by a cardiologist when necessary. The smoke was not a limitation; therefore, in the literature, the smokers have a higher failure rate of implants compared with the nonsmokers (3.5% vs. 1.9%, respectively) (PJETURSSON et al., 2008).

A total of 12 implants were placed in 6 patients who were evaluated clinically and through CBCT, or panoramic, or periapical radiographs, order to verify previously the site. As a protocol, there were some oral conditions also observed previously the surgery such as periapical infectious focus, periodontal disease, and carious lesions.

The surgical technique selected for all patients was the “atraumatic” sinus lift, described by Summers (1994c). This step began with drilling in the canine fossa with a trocater (Stortz®, Germany) with a lumen of 5 mm in diameter, in which through the lumen the endoscope with rigid optical fiber (Stortz®, Germany) of 30° and 0° (Fig. 1A) was inserted into the MS, and all image was captured with a Panasonic® camera (Tokyo, Japan) with a xenon light source (Linvatec®, USA) during all surgical steps.

Fentanyl (Janssen-Cilag, Sao Paulo, Brazil) was used for venous sedation followed by infiltrative anesthesia and nerve block with Mepivacaine 2% with adrenaline 1:100.000 (Mepiadre®, DFL, Rio de Janeiro, Brazil). An incision was made in the crest of the alveolar ridge accompanied by a discharge incision in the mesial zone, with mucoperiosteal detachment exposing the remaining bone crest, followed by initial perforation with a spherical drill under abundant irrigation of 0.9% saline at a speed of 1500 rpm until the bone cortical limit of the sinus floor.

Afterward, a 2 mm spiral drill was used also up to the cortical of the maxillary sinus, with confirmation of the measurement obtained with an indicator (Fig. 2A) (Nobel Biocare©) introduced into the bone perforation and a periapical radiograph (XCP radiographic film positioner, Dentisply®, Illinois, USA) and x-ray Spectro II device (Dabi-Atlante, Brazil).

Once the measurements were confirmed, the 2/3 pilot drill and 3 mm spiral drill were continued. The next step consisted of using osteotome 3i© (Fig. 1B) number 3, with the tip of the instrument in a concave shape, fracturing the cortical floor of the maxillary sinus. In this step, with the osteotome and bone carrier 3i© (Fig. 1C), the bone graft was inserted into the sinus cavity, always respecting the lower limit of the maxillary sinus to the active tip osteotome, using a xenograft (Bio-Oss®, Geistlich Biomaterials, Wolhusen, Switzerland) with small granules (about 0.5cc), for each implant site (NKENKE et al., 2002). After the placement of the graft and before implant placement, again the indicator was inserted into the cavity and a new periapical transoperative radiograph was taken, establishing an effective parameter to confirm the implant length.

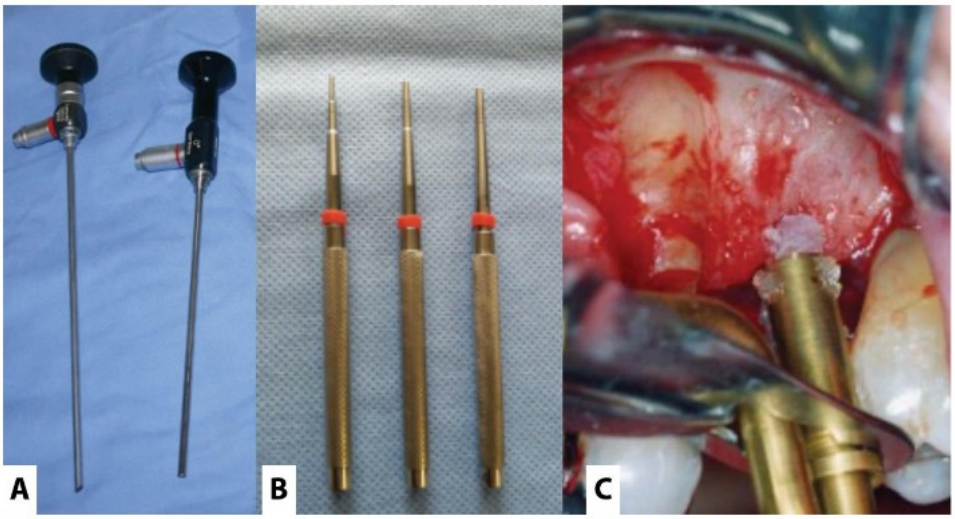

Figure 1 - A. Endoscopes used in the transoperative; B. Osteotomes kit for Summers technique; C. Instrument to take the graft and insert it within socket-formed.

The patients received dental implants MK III (TiUnite, Nobel Biocare©) (Fig. 2B) and Osseotite (3i©), with lengths between 8.5 to 13.0 mm and regular diameter (3.75 or 4.0 mm). The sutures were performed on a horizontal mattress and simple stitches with 5-0 nylon monofilament suture (Ethicon®, Johnson & Johnson, Sao Paulo, Brazil). It was applied infiltrative anesthesia with Bupivacaine 0,5% without vasoconstrictor (Neocaína®, Cristália, Brazil) to prolongate the comfort post-operative. The drug prescription followed 1,750 mg daily of Amoxicillin with Clavulanate Acid (Clavulin BD® 875 mg, SmithKlineBeechan, Rio de Janeiro, Brazil), beginning one day before the procedure, for 7 days; a steroid anti-inflammatory Betamethasone (Celestone® 2 mg, ScheringPlough, Sao Paulo, Brazil) also initiating two days before the procedure with 8 mg, 6 mg one day before the surgery, 4 mg at the surgical day, and 2 mg in the next day post-operative. For analgesia, immediately after

the surgery was taken hydrochloride of tramadol (Tramal® 50 mg, Searle, Sao Paulo, Brazil) intravenously. For home was prescribed hydrochloride of paracetamol with codeine (Tylex® 30 mg, the dose of 60 mg/day, Janssen-Cilag, Sao Paulo, Brazil) for 3 days, 5 drops of Rinosoro® (Farmasa, Sao Paulo, Brazil) in the nostril ipsilateral to the surgery 4-fold per day for 5 days, and paracetamol 750 mg when necessary. Besides, the patients were informed about all necessary standard cares to avoid postoperative intercurrences.

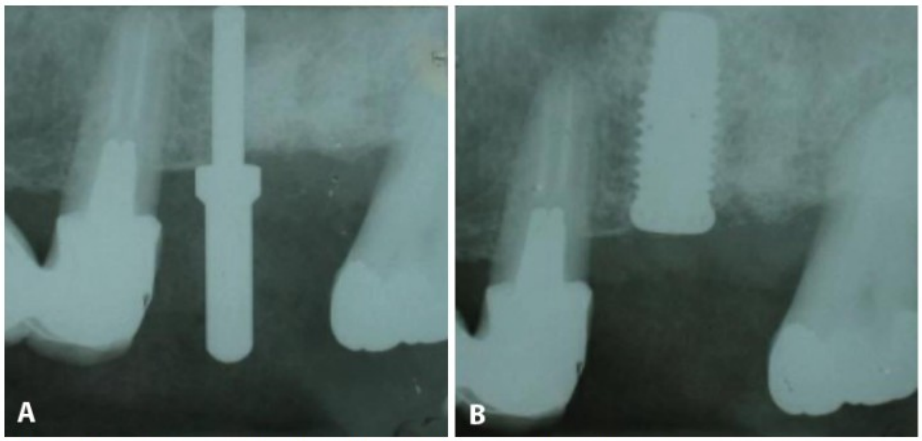

Figure 2 - A. Periapical radiograph of indicator positioned into the bone perforation; B. Periapical x-ray of the implant placed.

During the surgical procedure, using the endoscope (Fig. 3A), it was verified some intercurrences such as bone graft invading the maxillary sinus, which was removed and, according to the protocol pre-established, which follows rigorous sinus washing with 0.9% saline solution, aspirating all content, repairing the membrane with Instant® (Ethicon®, Johnson & Johnson, Scotland), and new material was inserted (patient #6a) (Fig. 3B); and a perforation was detected and adequately treated (patient #1a) (Fig. 3C).

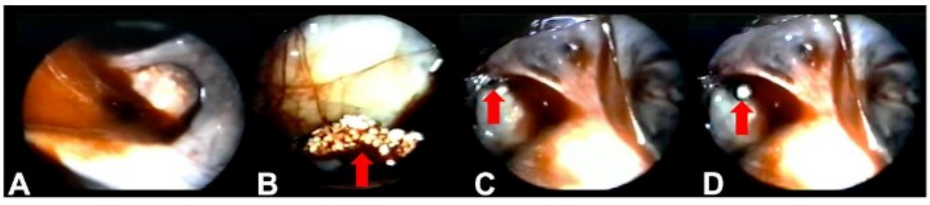

Figure 3 – Endoscopic views. A. Top view of an elevated site; B. Removal of the graft leakage in the maxillary sinus (arrow); C. Sinus membrane perforated (arrow), suggesting proximity to sinus septum; D. Sinus membrane perforated with an indicator inside the sinus (arrow).

Post-surgical Clinical Evaluation

The patient was followed-up routinely in the postoperative and reviews, for qualitative analysis of the physical status. Classical methods were used to verify the sinus lift and implant, clinically, such as the lack of mobility and other signs and symptoms like pain, inflammation, and suppuration (PELED et al., 2003). Absence of mobility can be considered the main observation in the implant assessment, and the endpoint for the failure of treatment (SIMSEK AND SIMSEK, 2003) and was evaluated for dichotomous analysis (presence or absence). On this hand, also was evaluated the inflammation, perforation, and implant loss. The nasal bleeding, persistent edema, and inflammatory profile were also observed. After 6-months from the surgery, all patients were contacted to follow-up and to follow the prosthetic phase.

Statistical analysis

After evaluation of the normal distribution (D'Agostino & Pearson test), the means and standard deviations were subjected to Student's paired t-test, defining significant differences for $p<0.05$. It was used the software GraphPad Prism (v.8.0, San Diego, California, USA). Statistical analysis was performed for the following parameters: residual ridge, bone height gain, and final bone height obtained.

RESULTS

The period of 10 years for the installed implants was completed between 20152016. Only one implant was lost (patient #4), achieving the survival rate of 91.66% after 10 years. It was unrelated to any surgical complications like pain or exacerbated edema. There was no intercurrence reported or contamination or still loss of the bone graft material.

In the trans- and postoperative, it was verified from 12 sites prepared with the Summers technique and implants installed, there is no implant with mobility or adverse/persistent inflammation. Otherwise, two sinus membranes were ruptured (16.66%), patients #1a and #6a, verified by endoscopic evaluation. Therefore, this complication did not cause any contra-indication for implant placement. Table 1 shows the data obtained for membrane integrity.

Table 1. Integrity of the maxillary sinus membranes per patient.

Patients	Number of sites for sinus lift / Implant(s)	Number of sites with membrane perforation	Implant mobility
# 1	3	1	no
# 2	1	no	no
# 3	1	no	no
# 4	1	no	no
# 5	4	no	no
# 6	2	1	no

All implants chosen were selected according to previous treatment planning, always with the regular diameter (3.75 mm or 4.0 mm) which is considered a minimum diameter indicated for this region and short and standard length (AL-JOHANY et al., 2017), respectively, three 8.5mm and nine regulars (four 10.0 mm, four 11.5 mm, and one 13.0 mm). At the surgery time, it was always available one lesser and one greater implant length than the planning, if necessary. One surgery overcame the expectations, achieving 9.0 mm of closed sinus lift and without membrane rupture.

The residual ridge under the MS was analyzed and ranged between 4.1 mm and 7.1 mm, with an average of 5.15 mm. The results obtained to the bone gain, in height, varying from 4.4 mm and 9.0 mm (Table 2), with the median for the vertical augmentation of 4.9 mm and the average of 5.54 mm. Thus, the sinus elevation collaborated with more than 50% permitting installing greater implants, which can give major predictability in the long-term.

Table 2. Residual ridge, height gain, implant length, membrane perforation and implant loss data.

PATIENTS	RESIDUAL RIDGE		IMPLANT LENGTH	HEIGHT GAIN	MEMBRANE PERFORATION	IMPLANT LOSS
	Site	Height				
# 1	a 15	6.7 mm	11.5 mm	4.9 mm	Yes	No
	b 16	4.3 mm	10.0 mm	5.9 mm	No	No
	c 17	7.1 mm	11.5 mm	4.7 mm	No	No
# 2	26	4.1 mm	10.0 mm	6.4 mm	No	No
# 3	16	4.3 mm	13.0 mm	9.0 mm	No	No
# 4	26	6.8 mm	11.5 mm	4.9 mm	No	Yes
# 5	a 15	5.1 mm	10.0 mm	5.2 mm	No	No
	b 16	4.4 mm	8.5 mm	4.3 mm	No	No
	c 25	5.3 mm	10.0 mm	4.9 mm	No	No
	d 26	4.4 mm	8.5 mm	4.7 mm	No	No
# 6	a 17	5.2 mm	11.5 mm	6.8 mm	Yes	No
	b 18	4.2 mm	8.5 mm	4.7 mm	No	No

The intragroup data for the reminiscent residual ridge (p=0.2618), implant length (p=0.8289), and bone gain (p=0.8289) were within the normality. The statistical comparison between the reminiscent bone and the final quantity obtained after surgery was extremely significant (p<0.0001) (Fig. 4). Normal distribution was observed by the normal Q-Q graph (Fig. 4), suggesting major predictability with the final bone height reached.

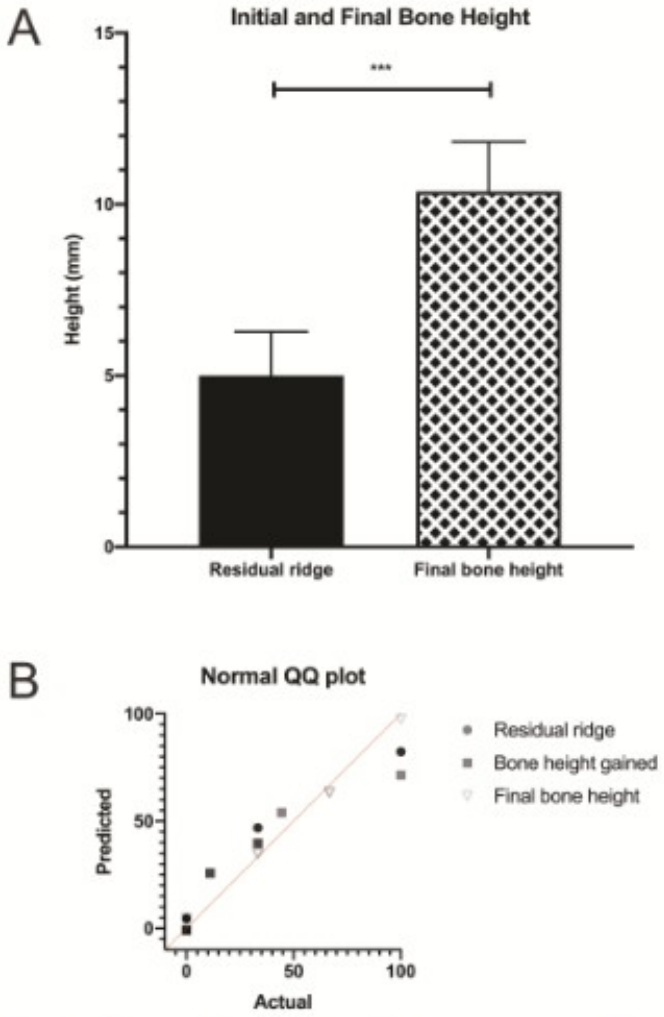

Figure 4 - A. Statistical significance found after comparison between initial bone (reminiscent) and final bone height; B. Normal distribution of residual bone, bone height gained, and final height achieved.

DISCUSSION

Success and Survival rate

Currently, the success rate of dental implants is high, making it a predictable reality with rates above 90% (FERRIGNO et al., 2006). The implant survival rate

was analyzed by a systematic review (TAN et al., 2008), which inserted the dental implant in combination with transalveolar sinus lifting like was proposed for this study. It included 19 articles with an average follow-up of at least 1 year after loading, which can be considered a short-term evaluation of analysis when compared to 10 years of follow-up studied in this article.

Even so, the estimated survival rate of 92.8% (95%CI: 87.4-96.0%) after 3 years, further 10.5% (95%CI: 3.6-28.9%) of subjects experiencing implant loss at the equivalent period. Fermergard and Astrand (2008) attained a similar result for the survival rate (94%) after three years follow up. Gabbert et al. (2009) reported an implant survival rate of 93.5%, all due to a lack of osseointegration in the first 6 months. At the momentum, this research may suggest new parameters for the long-term survival rate of 91.66% (12 implants placed) after 10 years, with no significant difference compared to 3 years reported by Tan et al. (2008). Pérez-Martínez et al. (2015) assessed the sinus lifting atraumatic technique without bone graft and reported in a meta-analysis the implant survival rates ranging between 93.5% and 100%.

Survival rate and Residual bone height

An interesting aspect is the comparison of the survival rate with the mean residual bone height, which was compared in some studies (LEBLEBICIOGLU et al., 2005; NEDIR et al., 2006; FERMERGÂRD AND ASTRAND, 2008; LAI et al., 2008; NEDIR et al., 2009; NEDIR et al., 2009 and 2010; SENYILMAZ AND KASABOGLU, 2011; BRUSCHI et al., 2012). Nedir et al. (NEDIR, BISCHOF et al., 2006 and 2009; NEDIR, NURDIN et al., 2009] recorded an implants survival rate of 100% in 1, 3, and 5 years of follow-up, equally obtained by Senyilmaz and Kasaboglu (2011) after 2 years, with a respective residual average bone height of 5.4 mm and between 5 and 10 mm. Leblebicioglu et al. (2005) reported a less survival rate (97.3%) with a residual bone of 9.1 mm. Fermergard and Astrand (2008) obtained a survival rate of 96.0% with a residual bone of 6.3 mm. Nedir et al. (2010), updated values after three years, with a lesser survival rate of 94%.

The survival rate of 95.4% with the lowest mean residual bone height (2.11 mm) was found by Bruschi et al. (2012) after 10.43 (±5.01) years of follow-up. Already Lai et al. (2008) reported survival rates of 95.2% residual ridges of 6.4 (±1.97) mm. This study had an average of residual bone height 5.15 mm and survival rate of 91.66% after 10 years, slightly lesser than Bruschi et al. (2012) which can be justified for the sample number studied.

A minimum residual bone height between the crest of the alveolar ridge and the maxillary sinus floor can permit to achieve the primary stability for the insertion of the implants at the same surgical time at the Osteotome technique (KOMARNYCKH AND LONDON, 1998; SUMMER, 1998; ROSEN, SUMMERS et al., 1999; TOFFLER 2002 and 2004a,b; HATANO et al., 2004; JOHN AND WENZ, 2004). By the way, for the association of implants placed with atraumatic sinus elevation, the residual bone height plays a significant role in implant survival. Thus, the minimum measure adopted for this study was 4 mm of remaining bone height (KOMARNYCKH AND LONDON, 1998; SUMMER, 1998; ROSEN et al., 1999; TOFFLER 2002 and 2004a,b; HATANO et al., 2004; JOHN AND WENZ, 2004), although would be predictable 3.72% of loss of the implants in this residual height and survival rate decreased to 85.7% (residual bone height < 4 mm) [61], such as survival rate 2.0% in residual bone with a height between 5 and 8mm [23], and a survival rate of 96% for residual bone height was > 5 mm (ROSEN et al., 1999). Similar results were found in a prospective study (PJETURSSON et al., 2009) with survival rates of 91.3% for sites with a residual bone height of < 4 mm, 90% for sites with 4-5 mm, and 100% survival rate for a residual height of > 5 mm.

Bone graft

Analyzing the use of bone graft biomaterial available to help in the surgery proposed, many varied origins can be found (autogenous, homogeneous, xenogenous, and alloplastic) (COATOAM AND KRIEGER, 1997; HURZELER et al., 1997a,b; SMILER, 1997; GARG, 1999; RAGHOEBAR et al., 1999; CAVICCHIA et al., 2001; RAGHOEBAR et al., 2001; HATANO et al., 2004). For this work opted for the xenogenic and osteoconductive material because it has the major scientific support (Bio-Oss®, Geistlish©), thereby preventing a second surgical site comparing with the autogenous, and with an amount of biomaterial available without limitations. The quantity employed was 0.5 cm3 based on the results of Nkenke et al. (2002).

Height gain in maxillary sinus elevation and Endoscope

The goal of this work was furthermore to verify what happens with the MS membrane in the sinus lifting surgery by Summers technique employing the endoscopic analysis. Currently, this study has the greatest time of a follow-up in the literature with this methodology of evaluation. Since the technique was published in 1994, it has been widely utilized and the main advantage reported is the localized access and the minimization of the contact with the membrane (TOFFLER, 2002 and 2004a,b).

Another interesting subject-related and still questionable is how much it is possible to gain safely in height using this technique. A study developed by Wiltfang et al. (2000) showed dissected skulls with a sagittal section in the sinus region after underwent sinus elevation by the atraumatic technique, to evaluate the limit of membrane lifting to prevent perforation. The values reached between 4 and 8 mm, but the authors reported 24% of the membrane rupture and concluded a safe elevation up to 5 mm. Another study also with human cadavers (n=25) confirmed the membrane elevation between 4 and 8 mm (REISER et al., 2001). The identical numbers, without membrane perforation (ENGELKE AND DECKWER, 1997), was confirmed in a study using an endoscope. This work corroborates that the 5 mm are safe for lifting and confirmed the simplicity of the technique, with 58.33% sites elevating up to 5 mm, with only one perforation.

Although this value (5 mm) has represented a standardized limit, review studies (LEBLEBICIOGLU et al., 2005; NEDIR et al., 2006; FERMERGÂRD AND ASTRAND, 2008 and 2012; NEDIR, BISCHOF et al., 2009; NEDIR, NURDIN et al., 2009 and 2010; HE et al., 2013) have reported values of 2.5 mm for the lowest sinus height gained (NEDIR, BISCHOF et al., 2006; NEDIR, NURDIN et al., 2009; HE et al., 2013) and other gains of 4.4 mm (FERMERGÂRD AND ASTRAND, 2008 and 2012). This value (4.4 mm) was achieved after 1 and 5 years, in both studies with the same result once it was utilized the same samples. Therefore, for a similar period and patients, other studies (NEDIR, NURDIN et al., 2009, 2010) obtained divergent results, without bone graft, reporting respective gain values of 2.5 (± 1.2) mm and 3.2 (± 1.3) mm, what is contrasting, and it can lead to possible bias of analysis. Pérez-Martínez et al. (2015) using the sinus lifting atraumatic technique, also without bone graft, reached a mean bone height gain of 3.43 mm, next to Nedir, Nurdin et al. (2009, 2010). About 2 years, Leblebicioglu et al. (2005) achieved a lifting value of 3.3 (± 1.6) mm. Also, Zitzmann and Schaerer (1998) and Cavicchia et al. (2001) already reported similar values, respectively, 2.9 mm and 3.5 mm. In the literature, Komarnyckyj and London (1998) reported preoperative measures of bone heights lesser than the minimum proposed in this study (4.0 mm), varying between 3 and 9 mm with average 5.4 mm, and yielded gains between 2 and 7 mm with average 3.25 mm, which presented in some cases 2 mm above than the standardized (5.0 mm).

On the other hand, in this study, there was a significant percentual (41.66%) achieving superior values (> 5.0-9.0 mm) presenting only one membrane rupture which was associated with bone graft invasion within the sinus region. Highlight for the elevation of 9 mm without perforation, with the implant success rate after 10 years. Specifically, it can be considered completely nonstandard

and is unrecommended to try out it without endoscope auxiliary. Under endoscopic control, Baumann and Ewers (1999) also presented case reports treated with 13 mm length-implants in 7 patients, who were divided among 5 participants with the previous bone height of 6 to 8 mm and 2 patients with a prior bone height of 3 to 5 mm. They concluded that even using the endoscope, there were occurrence perforations of 5 of 6-membranes when it was lifted more than 5.0 mm. Conversely, another rupture that happened the elevation was very close to 5.0 mm, precisely, 4.9mm.

The endoscope analysis guarantees the inner access and visualization to evaluate the membrane and its behavior during the surgical procedure (WILTFANG et al., 2000) is considered the only internal technique to help the professional in the transoperative, reducing a possible morbidity face to intercurrences, and the migration of the grafting material into the sinus (ENGELKE AND DECKWER, 1997; WILTFANG et al., 2000; NKENKE et al., 2002; SCHLEIER, 2008). In this study, there was only one episode of graft material leaking into the sinus (Fig. 3B), in which the sinus was treated as previously described and new material was inserted, proving the effectiveness of using the endoscope. Besides, Nkenke et al. (2002) summarized in the study that when the sinus membrane needed to be lifted greater than 3 mm, it is recommended an endoscopic control.

Even with few reports in the literature on the use of the endoscope in the Osteotome technique, Engelke and Deckwer (1997) studying 8 sites did not observe perforation of the sinus membrane. Nkenke et al. (2002) observed 18 sites and only 1 perforation occurred (5.55%). Berengo et al. (2004) evaluated 16 implants placement and experienced two perforations (12.5%). In this study, from the 12 sites evaluated, the sinus membrane was perforated at two sites (16.66%). This episode may be due to the adjacent location with the sinus septum (Fig. 3C). By the way, these results still are encouraging and stimulating once the atraumatic lifting with osteotomes had percentages of perforation lesser than found in the lateral bone window (conventional technique), like 24.0% (REISER et al., 2001), 27.5% (WANNFORS et al., 2000), 28.0% (SHOLMI et al., 2004), and 35.0% (SMALL et al., 1993; VAN DEN BERGH et al., 2000a,b).

Moreover, this work may suggest an elevation in the transalveolar approach up to 5.5 mm in healthy subjects, elevating 0.5 mm the standard proposed in the literature (ENGELKE AND DECKWER, 1997). Nevertheless, these results must be carefully interpreted, evaluating the risk-benefits due to only 12 sites assessed.

Endoscope access site x Anatomical considerations

For a standard place to introduce the endoscope into the maxillary sinus was opted the canine fossa, according to the previous reports (ENGELKE AND DECKWER, 1997; NKENKE et al., 2002; BERENGO et al., 2004). This decision was supported for the necessity dislocation of the middle nasal shell5, the frequent removal of the uncinate process (ARCHER, 2003), and occasionally the necessity for an enlargement of the maxillary sinus ostium (CHRISTMAS JUNIOR AND KROUSE, 1996), what could cause postoperative hemorrhage, and in the case of ostium enlargement, the greatest concern towards preserving the nasolacrimal duct. These anatomical reasons contributed decisively to the choice of access into maxillary sinus by the canine fossa.

Final considerations

This study can agree with many authors concerning the endoscope use concomitantly with the Summers technique, referring to disadvantages the need for a second surgeon, additional equipment for endoscopy, the increased surgical time, and financial cost. Otherwise, it can give excellent support to avoid trans- and postoperative problems.

CONCLUSION

Within the limitations of this long-term study, it can conclude the Summers technique caused perforations in the MS membrane, which would be imperceptible without an endoscope, and may suggest a secure elevation in the transalveolar approach up to 5.5 mm in healthy patients, due to achieving an increased average of vertical height 5.37 mm, ensuring the integrity of the sinus membrane, but this data should be carefully interpreted because of the limited number of samples, suggesting more long-term studies. Moreover, it was reached a high implants survival rate (91.66%) after 10 years. Otherwise, the application of this methodology performing simultaneously with the osteotome technique was tough, besides there was an elevated financial cost for the treatment, and a more complex approach became the association not much attractive to be adopted in the routine, but the use is encouraged.

REFERENCES

1. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991;101:56-64.

2. Misch CE. Cirurgia para levantamento do seio maxilar e enxertos sinusal. In:Misch, C. E. Implantes dentários comtemporaneos. 2a ed., Sao Paulo, Ed. Santos, 2002;469- 495.

3. Nkenke E, Schlegel A, Schultze-Mosgau S, Neukam FW, Wiltfang J. The endoscopically controlled osteotome sinus floor elevation: a preliminary prospective study. Int J Oral Maxillofac Implants 2002;17:557-566.

4. Reiser GM, Rabinovitz Z, Bruno J, Damoulis PD, Griffin TJ. Evaluation of maxillary sinus membrane response following elevation with the crestal osteotome technique in human cadavers. Int J Oral Maxillofac Implants 2001;16:833-840.

5. Timenga NM. Maxillary sinus floor elevation surgery. A clinical, radiographic and endoscopic evaluation. Clin. Oral Implants Res 2003;14:322-328.

6. Pjetursson BE, Tan WC, Zwahlen M, Lang NP. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. J Clin Periodontol 2008;35:216-240.

7. Nkenke E, Stelzle F. Clinical outcomes of sinus floor augmentation for implant placement using autogenous bone or bone substitutes: A systematic review. Clin Oral Implants Res 2009;20:124-133.

8. Jensen T, Schou S, Gundersen HJG, Forman JL, Terheyden H, Holmstrup P. Bone- to-implant contact after maxillary sinus floor augmentation with Bio-Oss and autogenous bone in different ratios in mini pigs. Clin Oral Implants Res 2013;24:635- 644.

9. Corbella S, Taschieri S, Del Fabbro M. Long-term outcomes for the treatment of atrophic posterior maxilla: A systematic review of literature. Clin Implants Dent Relat Res 2015;17:120-132.

10. Esposito M, Grusovin MG, Rees J, Karasoulos D, Felice P, Alissa R, Coulthard P. Effectiveness of sinus lift procedures for dental implant

rehabilitation: A Cochrane systematic review. Eur J Oral Implantol 2010;3:7-26.

11. Thoma DS, Zeltner M, Husler J, Hammerle CHF, Jung RE. EAO Supplement Working Group 4 - EAO CC 2015 Short implants versus sinus lifting with longer implants to restore the posterior maxilla: A systematic review. Clin Oral Implants Res 2015;26:154-169.

12. Starch-Jensen T, Aludden H, Hallman M, Dahlin C, Christensen A-E, Mordenfeld A. A systematic review and meta-analysis of long-term studies (five or more years) assessing maxillary sinus floor augmentation. Int J Oral Maxillofac Surgery 2018;47:103-116.

13. Ting M, Rice JG, Braid SM, Lee CYS, Suzuki JB. Maxillary sinus augmentation for dental implant rehabilitation of the edentulous ridge: A comprehensive overview of systematic reviews. Imp Dent 2017;26:438-64.

14. Tatum JH. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986;30:207-229.

15. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium 1994; 15:152,154-156.

16. Summers RB. The osteotome technique: Part 2--The ridge expansion osteotomy (REO) procedure. Compendium 1994;15:422-436.

17. Summer RB. The osteotome technique: Part 3--Less invasive methods of elevating the sinus floor. Compendium 1994;15:698-704.

18. Summer RB. The osteotome technique: Part 4--Future site development. Compend Contin Educ Dent 1995;16:1080-1099.

19. Summer RB. Conservative osteotomy technique with simultaneous implant insertion Dent Implantol Update 1996;7:49-53.

20. Summer RB. Sinus floor elevation with osteotomes. J Esthet Dent 1998; 10:164-71.

21. Pjetursson BE, Lang NP. Sinus floor elevation utilizing the transalveolar approach. Periodontol 2000 2014;66:59-71.

22. Ferrigno N, Laureti M, Fanali S. Dental implant placement in conjunction with osteotome sinus floor elevation: 12-year life-table analysis from a prospective study on 588 ITI implants. Clin Oral Implants Res 2006;17:194-205.

23. Jensen OT, Shulman LB, Block MS, Iacono VJ. Report of the Sinus Consensus Conference of 1996. Int J Oral Maxillofac Implants 1998;13:11-45.

24. Pérez-Martínez S, Martorell-Calatayud L, Penarrocha-Oltra D, García-Mira B, Penarrocha-Diago M. Indirect sinus lift without bone graft material: Systematic review and meta-analysis. J Clin Exp Dent 2015;7:e316-e319.

25. Toffler M. Osteotome-mediated sinus floor elevation: A clinical report. Int J Oral Maxillofac Implants 2004;19:266-273.

26. Krennmair G, Krainhofer M, Schmid-Schwap M, Piehslinger E. Maxillary sinus lift for single implant-supported restorations: a clinical study. Int J Oral Maxillofac Implants 2007;22:351-358.

27. Pjetursson BE, Ignjatovic D, Matuliene G, Bragger U, Schmidlin K, Lang NP. Transalveolar maxillary sinus floor elevation using osteotomes with or without grafting material. Part II: Radiographic tissue remodeling. Clin Oral Implants Res 2009;20:677-683.

28. Leblebicioglu B, Ersanli S, Karabuda C, Tosun T, Gokdeniz H. Radiographic evaluation of dental implants placed using an osteotome technique. J Periodontol 2005;76:385-390.

29. Nedir R, Bischof M, Vazquez L, Szmukler-Moncler S, Bernard JP. Osteotome sinus floor elevation without grafting material: a 1-year prospective pilot study with ITI implants. Clin Oral Implants Res 2006;17:679-686.

30. Lai HC, Zhang ZY, Wang F, Zhuang LF, Liu X. Resonance frequency analysis of stability on ITI implants with osteotome sinus floor elevation technique without grafting: a 5-month prospective study. Clin Oral Implants Res 2008;19:469-475.

31. Senyilmaz DP, Kasaboglu O. Osteotome sinus floor elevation without bone grafting and simultaneous implant placement in the atrophic maxilla: a pilot study. Indian J Dent Res 2011;22:786-789.

32. Van Den Bergh JP, ten Bruggenkate CM, Disch FJ, Tuinzing DB. Anatomical aspects of sinus floor elevations. Clin Oral Implants Res 2000;11:256-265.

33. Kim MJ, Jung UW, Kim CS, Kim KD, Choi SH, Kim CK, Cho KS. Maxillary sinus septa: prevalence, height, location, and morphology. A reformatted computed tomography scan analysis. J Periodontol 2006;77:903-908.

34. Ulm CW, Solar P, Gsellmann B, Matejka M, Watzek G. The edentulous maxillary alveolar process in the region of the maxillary sinus - a study of physical dimension. Int J Oral Maxillofac Surg 1995;24:279-282.

35. Schwarz L, Schiebel V, Hof M, Ulm C, Watzek G, Pommer B. Risk factors of membrane perforation and postoperative complications in sinus floor elevation surgery: Review of 407 augmentation procedures. J Oral Maxillofac Surgery 2015;73:1275-1282.

36. Tükel H, Tatli U. Risk factors and clinical outcomes of sinus membrane perforation during lateral window sinus lifting: Analysis of 120 patients. Int J Oral Maxillofac Surgery 2018;47:1189-1194.

37. Aimetti M, Romagnoli R, Ricci G, Massei G. Maxillary sinus elevation: the effect of macrolacerations and microlacerations of the sinus membrane as determined by endoscopy. Int. J Periodontics Restorative Dent 2001;21:581-589.

38. Regev E, Smith RA, Perrott DH, Pogrel MA. Maxillary sinus complications related to endosseous implants. Int J Oral Maxillofac Implants 1995;10:451-461.

39. Sholmi B, Horowitz I, Kahn A, Dobriyan A, Chaushu G. The effect of sinus membrane perforation and repair with Lambone on the outcome of maxillary sinus floor augmentation: a radiographic assessment. Int J Oral Maxillofac Implants 2004;19:559-562.

40. Engelke W, Deckwer I. Endoscopically controlled sinus floor augmentation. A preliminary report. Clin Oral Implants Res 1997;8:527-531.

41. Wiltfang J, Schultze-Mosgau S, Merten HA, Kessler P, Ludwig A, Engelke W. Endoscopic and ultrasonographic evaluation of the maxillary

sinus after combined sinus floor augmentation and implant insertion. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89:288-291.

42. Schleier P. EIS - Endoscopically assisted internal sinus lift. Tuttlingen, Germany, EndoPress, 2008.

43. Testori T, Drago L, Wallace SS, Capelli M, Galli F, Zuffetti F, Parenti A, Deflorian M, Fumagalli L, Weinstein RL, Maiorana C, Di Stefano D, Valentini P, Gianni AB, Chiapasco M, Vinci R, Pignataro L, Mantovani M, Torretta S, Pipolo C, Felisati G, Padoan G, Castelnuovo P, Mattina R, Del Fabbro M. Prevention and Treatment of Postoperative Infections after Sinus Elevation Surgery: Clinical Consensus and Recommendations. Int J Dent 2012;365809.

44. Tonetti MS, Hammerle CHF. Advances in bone augmentation to enable dental implant placement: Consensus Report of the Sixth European Workshop on Periodontology. J Clin Periodontol 2008;35:168-172.

45. Jensen O, Block MS, Iacono V. 1996 Sinus Consensus Conference Revisited in 2016. Int J Oral Maxillofac Implants 2016;31:505-508.

46. Peled M, Ardekian L, Tagger-Green N, Gutmacher Z, Machtei E. Dental Implants in Patients with Type 2 Diabetes Mellitus: A Clinical Study. Imp Dent 2003; 12:116-22.

47. Simsek B, Simsek S. Evaluation of success rates of immediate and delayed implants after tooth extraction. Chin Medical J 2003;116:1216-1219.

48. Al-Johany SS, Al Amri MD, Alsaeed S, Alalola B. Dental Implant Length and Diameter: A Proposed Classification Scheme. J Prosthodont 2017;26:252-260.

49. Tan WC, Lang NP, Zwahlen M, Pjetursson BE. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. Part II: transalveolar technique. J Clin Periodontol 2008;35:241-254.

50. Fermergârd R, Astrand P. Osteotome sinus floor elevation and simultaneous placement of implants--a 1-year retrospective study with Astra Tech implants. Clin Implant Dent Relat Res 2008;10:62-69.

51. Gabbert O, Koob A, Schmitter M, Rammelsberg P. Implants placed in combination with an internal sinus lift without graft material: an analysis of short-term failure. J Clin Periodontol 2009;36:177-183.

52. Leblebicioglu B, Ersanli S, Karabuda C, Tosun T, Gokdeniz H. Radiographic evaluation of dental implants placed using an osteotome technique. J Periodontol 2005;76:385-390.

53. Lai HC, Zhang ZY, Wang F, Zhuang LF, Liu X. Resonance frequency analysis of stability on ITI implants with osteotome sinus floor elevation technique without grafting: a 5-month prospective study. Clin Oral Implants Res 2008;19:469-475.

54. Senyilmaz DP, Kasaboglu O. Osteotome sinus floor elevation without bone grafting and simultaneous implant placement in the atrophic maxilla: a pilot study. Indian J Dent Res 2011;22:786-789.

55. Nedir R, Bischof M, Vazquez L, Nurdin N, Szmukler-Moncler S, Bernard JP. Osteotome sinus floor elevation technique without grafting material: 3-year results of a prospective pilot study. Clin Oral Implants Res 2009;20:701-707.

56. Nedir R, Nurdin N, Szmukler-Moncler S, Bischof M. Placement of tapered implants using an osteotome sinus floor elevation technique without bone grafting: 1-year results. Int J Oral Maxillofac Implants 2009;24:727-733.

57. Nedir R, Nurdin N, Vazquez L, Szmukler-Moncler S, Bischof M, Bernard JP. Osteotome sinus floor elevation technique without grafting: a 5-year prospective study. J Clin Periodontol 2010;37:1023-1028.

58. Bruschi GB, Crespi R, Capparè P, Gherlone E. Transcrestal sinus floor elevation: a retrospective study of 46 patients up to 16 years. Clin Implant Dent Relat Res 2012;14:759-767.

59. Hatano N, Shimizu Y, Ooya K. A clinical long-term radiographic evaluation of graft height changes after maxillary sinus floor augmentation with a 2:1 autogenous bone/xenograft mixture and simultaneous placement of dental implants. Clin Oral Implants Res 2004;15:339-345.

60. John HD, Wenz B. Histomorphometric analysis of natural bone mineral for maxillary sinus augmentation. Int J Oral Maxillofac Implants 2004;19:199-207.

61. Komarnyckh OG, London RM. Osteotome single-stage dental implant placement with and without sinus elevation: a clinical report. Int J Oral Maxillofac Implants 1998;13:799-804.

62. Rosen PD, Summers R, Mellado JR, Salkin LM, Shanaman RH, Marks MH, Fugazzotto PA. The bone-added osteotome sinus floor elevation technique: multicenter retrospective report of consecutively treated patients. Int J Oral Maxillofac Implants 1999;14:853-858.

63. Toffler M. Staged sinus augmentation using a crestal core elevation procedure and modified osteotomes to minimize membrane perforation. Pract Proced Aesthet Dent 2002;14:767-776.

64. Toffler M. Osteotome-mediated sinus floor elevation: a clinical report. Int J Oral Maxillofac Implants 2004;19:266-273.

65. Toffler M. Minimally invasive sinus floor elevation procedures for simultaneous and staged implant placement. NY State Dent J 2004;70:38-44.

66. Pjetursson BE, Rast C, Bragger U, Zwahlen M, Lang NP. Maxillary sinus floor elevation using the osteotome technique with or without grafting material. Part I - Implant survival and patient's perception. Clin Oral Implants Res 2009;20:667-676.

67. Coatoam GW, Krieger JT. A four-year study examining the results of indirect sinus augmentation procedures. J Oral Implantol 1997;23:117-127.

68. Hurzeler MB, Quinones CR, Kirsch A, Gloker C, Schüpbach P, Strub JR, Caffesse RG. Maxillary sinus augmentation using different grafting materials and dental implants in monkeys. Part I. Evaluation of anorganic bovine-derived bone matrix. Clin Oral Implants Res 1997;8:476-486.

69. Hurzeler MB, Quinones CR, Kirsch A, Schüpbach P, Krausse A, Strub JR, Caffesse RG. Maxillary sinus augmentation using different grafting materials and dental implants in monkeys. Part III. Evaluation of autogenous bone combined with porous hydroxyapatite. Clin Oral Implants Res 1997;8:401-411.

70. Smiler DG. The sinus lift graft: basic technique and variations. Pract Periodontics Aesthet Dent 1997;9:885-893.

71. Garg AK. Augmentation grafting of the maxillary sinus for placement of dental implants: anatomy, physiology, and procedures. Implant Dent 1999;8:36-46.

72. Raghoebar GM, Batenburg RH, Timmenga NM, Vissink A, Reintsema H. Morbidity and complications of bone grafting of the floor of the maxillary sinus for the placement of endosseous implants. Mund. Kiefer. Gesichtschir 1999;3:65-69.

73. Raghoebar GM, Timmenga NM, Reintsema H, Stegenga B, Vissink A. Maxillary bone grafting for insertion of endosseous implants: results after 12-124 months. Clin. Oral Implants Res 2001;12:279-286.

74. Cavicchia F, Bravi F, Petrelli G. Localized augmentation of the maxillary sinus floor through a coronal approach for the placement of implants. Int J Periodontics Restorative Dent 2001;21:475-485.

75. He L, Chang X, Liu Y. Sinus floor elevation using osteotome technique without grafting materials: a 2-year retrospective study. Clin Oral Implants Res 2013;24:63- 67.

76. Fermergârd R, Âstrand P. Osteotome sinus floor elevation without bone grafts - a 3- year retrospective study with Astra Tech implants. Clin Implant Dent Relat Res 2012;14:198-205.

77. Zitzmann NU, Schaerer P. Sinus elevation procedures in the resorbed posterior maxilla. Comparison of the crestal and lateral approaches. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:8-17.

78. Baumann A, Ewers R. Minimally invasive sinus lift. Limits and possibilities in the atrophic maxilla (in German). Mund Kiefer Gesichtschir 1999;3:S70-S73.

79. Berengo M, Sivolella S, Majzoub Z, Cordioli G. Endoscopic evaluation of the bone- added osteotome sinus floor elevation procedure. Int J Oral Maxillofac Surg 2004;33:189-194.

80. Wannfors K, Johansson B, Hallman M, Strandkvist T. A prospective randomized study of 1- and 2-stage sinus inlay bone grafts: 1-year follow-up. Int. J. Oral Maxillofac Implants 2000;15:625-632.

81. Small SA, Zinner ID, Panno FV, Shapiro HJ, Stein JI. Augmenting the maxillary sinus for implants: report of 27 patients. Int J Oral Maxillofac Implants 1993;8:523- 528.

82. Van Den Bergh JPA, ten Bruggenkate CM, Krekeler G, Tuinzing DB. Maxillary sinus floor elevation and grafting with human demineralized freeze dried bone. Clin Oral Implants Res 2000;11:487-493.

83. Archer S. Functional endoscopic sinus surgery. Atlas Oral Maxillofac Surg Clin North Am 2003;11:157-167.

84. Christmas Junior DA, Krouse JH. Powered instrumentation in functional endoscopic sinus surgery. I: Surgical technique. Ear Nose Throat J 1996;5:33-40.