

Impact of early complications of sinus floor elevation and individual factors of the body on the long-term treatment results

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SUMMARY

Background. During sinus floor elevation surgery some complications and individual body factors may influence long term treatment results. The purpose of this study is to assess the correlation between the long-term success of sinus floor elevation surgery and the early complications of surgery as well as individual factors of the body.

Material and methods. The review of the current literature was conducted according to the PRISMA guidelines by using NCBI PubMed database. Only new articles there selected. Articles were searched from 2010 to 2015.

Results. 15 publications related to sinus floor elevation complications have been included in the review. Total 3369 sinus floor elevation were performed.

Conclusion. Sinus membrane perforation during lateral sinus floor elevation has negative effect on the long-term outcomes of the treatment. However, in case of osteotome sinus floor elevation surgery this complication has no influence on the long-term outcomes. Smoking, advanced age, low bone volume, thin and hypertrophic sinus membrane could increase a risk of complications.

Key words: sinus lift, sinus augmentation, sinus floor elevation complications, sinus membrane perforation, sinusitis, bone infection.

INTRODUCTION

Sinus floor elevation (SFE) surgery for the first time was described in 1980. Two main techniques have been developed – the lateral (direct) sinus floor elevation (LSFE) and osteotome (indirect) sinus floor elevation (OSFE). Since that time both these techniques have been continuously modified and improved. Despite the high proportion of successful treatment cases, some complications are still reported. One of most common complications is a perforation of sinus membrane. Other very important, but rare complications are sinusitis and bone infection. Some individual factors of body have also been identified as having a potential effect on the long-term outcomes of the treatment. Thus, the purpose of this review is to systematise complications and the influence of certain factors on the long-term outcomes of the treatment.

Tasks

1. To assess the relation between the long-term success of sinus floor elevation surgery and the perforation of sinus membrane.
2. To assess the relation between the long-term success of sinus floor elevation surgery and sinusitis as well as bone infection.
3. To assess the relation between the developed consultations and influencing factors of the body factors.

MATERIAL AND METHODS

Systemic review of literature has been performed according to the PRISMA criteria of data selection. Information sources were selected from PubMed, Medline and ScienceDirect databases. Key words used for search: sinus lift, sinus augmentation, sinus floor elevation complications, sinus membrane perforation, sinusitis, bone infection. The search according to the said keywords resulted in 1035 sources and as much as 250 publications were selected as matching the study scope. After the activation of filters and

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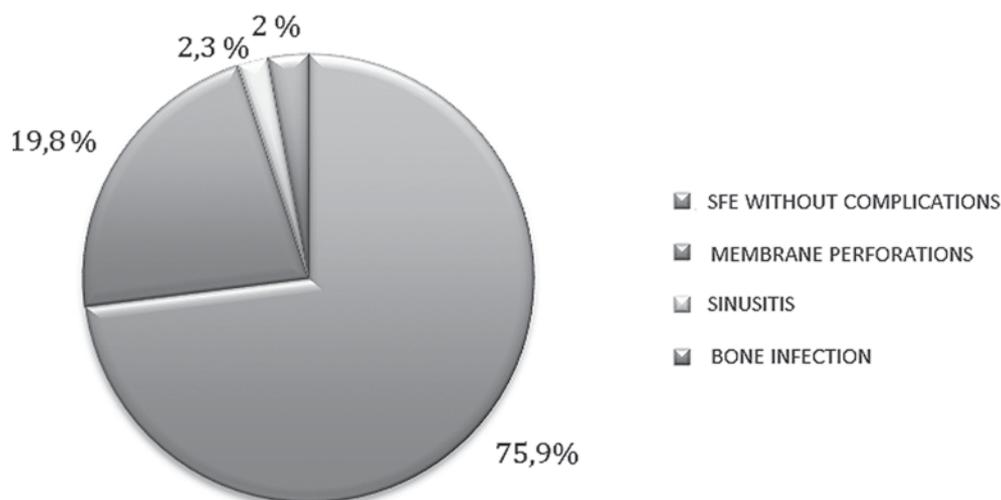


Fig. Incidence rate of the complications after the lateral sinus floor elevation surgery

application of screening criteria, 235 articles were rejected. 15 sources meeting the screening criteria have been included in the review.

RESULTS

Seven articles of 15 selected publications were related to the complications of the lateral sinus floor elevation surgery. Eight articles were associated with the complications of osteotome sinus floor elevation surgery. In total 3369 sinus floor elevation

comprised 19.8% (Figure).

The study by Patric J. Nolan *et al.* (1) focused mainly on the impact of perforations on the long-term outcomes of the treatment. Mean incidence of perforations in this study was 41%. Based on the data of this study, perforations are statistically significant factor making influence on the long-term outcomes of the treatment (p=0.0035) (Table 2). Among all failures (loss of the implants and/or a bone graft), in 70.8% of cases a bone graft or the implants were lost in the perforated membranes.

Table 1. Data associated with the lateral (direct) sinus floor elevation surgery

No.	Study	Year	Study duration (years)	Number of LSFE surgeries	Perforations	Sinusitis	Mean success of surgery (%)
1	Patric J. Nolan <i>et al.</i>	2014	3	359	150	20	93.3
2	Eric Oh <i>et al.</i>	2011	1	175	60	4	98.8
3	Istvan A. Urban <i>et al.</i>	2012	9	274	10	2	97.1
4	Yifat Manor <i>et al.</i>	2010	6	153	48	6	96.7
5	M. Beretta <i>et al.</i>	2014	5	246	14	2	98.3
6	Chyun-Suk Cha <i>et al.</i>	2014	6	217	35	1	96.5
7	Max J. Zinser <i>et al.</i>	2013	14	347	34	4	93.3
Total:			1-14	1771	351	42	Average: 96.6

Table 2. Effect of sinus membrane perforations on the complications

Study	Membrane condition	Number of LSFE implants	Number of fails (a simple bone graft and (or) implants) n	Number of fails %	p value
Patric J. Nolan <i>et al.</i>	Intact	209	7	3.4	p=0.0335 significant
	Perforated	150	17	11.3	
Eric Oh <i>et al.</i>	Intact	115	1	0.8	p<0.006 significant
	Perforated	60	3	5	
Chyun-Suk Cha <i>et al.</i>	Intact	381 implants	13 implants	3.4	p=0.7162 insignificant
	Perforated	65 implants	3 implants	4.6	

surgical interventions were performed and assessed in the studies. Of them, 1771 interventions were lateral sinus floor elevations (Table 1) and 1598 – osteotome sinus floor elevations (Table 8).

Sinus membrane perforations

Mean incidence of perforation in different studies has varied from 10% to 41%. Mean general incidence of the perforations in this review

In case of perforated membrane, sinus floor elevation surgery was unsuccessful in 11.3% of all cases (a bone graft was lost). At the same time, bone graft was lost only in 3.4% of cases when the membrane was intact.

Eric Oh *et al.* (2) also investigated the effect of membrane perforation on the long-term outcomes of the treatment (Table 2). Mean general incidence of the perforations was 34%. This study also demonstrated that membrane perforations are statistically significant factor for the long-term outcomes of the treatment (p<0.006).

Mean general incidence of the perforations at the study by Chyun-

Suk Cha *et al.* (6) accounted 16.1%. Based on the obtained data, perforations were not a statistically significant factor ($p=0.7162$). Also perforations were not a statistically significant factor in the study by M. Beretta *et al.* (5). Nevertheless, in these studies better results were obtained when the membranes were intact (Table 2).

Sinusitis, infection of bone graft

Based on data from the review of publications, sinusitis and bone infections are significantly rarer complications if compared with membrane perforations. Average incidence of sinusitis was 2.3%, while that of bone infection – 2%. It was determined that the incidence of these complications has not had statistically significant influence on the treatment outcome. However, these complications are much more dangerous than other potential complications during SFE.

Six sinusitis cases were reported in the study by Yifat Manor *et al.* (4) (Table 3) of 153 sinus floor elevation surgeries, but only three failures were reported requiring removing a transplant and the implants. This study has demonstrated that sinusitis can be a controlled process. Irreversible failure is experienced in case of active sinusitis. It has been stated in this study that in the event of active sinusitis a bone graft and the implants were removed. Active sinusitis has been diagnosed based on the following symptoms: stuffy nose or nose bleeding, headache, heaviness in the affected side of face-head, penetration of bone particles through a nose and gums.

All cases of sinusitis were examined and two statistically significant factors having negative influence on the long-term outcomes of the treatment were discovered (Table 3):

1. Previously diagnosed inflammations of sinus ($p=0.001$). Medical history of chronic sinusitis or earlier interventions on the sinus were discovered in the medical records of almost all patients suffering from sinusitis.

2. Thin sinus membrane ($p<0.0001$). Findings of computer tomog-

raphy and endoscopic examination revealed that sinus membrane (before SFE surgery) was significantly thinner in the patients diagnosed with sinusitis, as compared with that of other patients

Bone infection problem was addressed in the study by Istvan A. Urban *et al.* (3) eight cases of bone infection were diagnosed after 278 LSFE surgeries. The main conclusion of the investigators was as follows: in case of failure to timely diagnose and treat bone infection, the inflammation will eventually spread and damage sinus mucous membranes, thus removal of a bone graft and sinusitis becomes inevitable. Authors stated that if infection is diagnosed timely, all processes of infection can be controlled without affecting sinus cavity. The following main criteria have been indicated: 1) timely diagnosis of bone infection; 2) removal the infected graft only. It has been also suggested to rinse the remaining bone graft with a solution of antibiotics; 3) a new bone graft and implants should not be implanted immediately after the cleaning; 4) a new bone graft and implants should be implanted during the second phase. All eight cases of infections were successfully controlled in the study applying this protocol. The inflammation did not spread to the sinus mucous membranes. This has proved that process of bone graft infection not necessarily should spread. Implants were implanted into all of these sinuses during the second stage (24 pieces in total), and their mean survival during the period from the first to ninth year was 100%.

Table 3. The impact of sinus membrane perforations on the development of complications after LSFE

Study	LSFE implants	Perforations	Sinusitis	Failures (bone removal)
Yifat Manor <i>et al.</i>	153	48	6 3 – active (just after a surgery) 3 – chronic (occurring later) – five patients of 6 had chronic sinusitis before the surgery – in four cases out of 6 thinning of sinus membranes were discovered before the surgery by CT scan	3 All 3 cases were accompanied by active sinusitis and bone infections

Table 4. The impact of bone volume on the long-term treatment outcomes

Study	Bone volume	Mean success level, %	p value
Chyun-Suk Cha <i>et al.</i>	>5 mm	98.9	$p=0.3135$ insignificant
	<5 mm	96.5	
Max J. Zinser <i>et al.</i>	>5 mm	95.8	$p<0.004$ significant
	<5 mm	89.9	
Patric J. Nolan <i>et al.</i>	>5 mm	94.5	$p=0.0024$ significant
	<5 mm	73.7	

Influence of other factors

Influence of bone volume on the long-term outcomes of the treatment was assessed in three articles. All treatments revealed that more complications, such as loss of bone graft implants, occurred in case of low bone volume. Mean success levels were lower in such cases (Table 4). In the studies by Max J. Zinser *et al.* (7) and Patric J. Nolan *et al.* (1) small bone volume was statistically significant factor with a negative impact on the long-term treatment outcomes; this factor was found to be insignificant in the studies by Chyun-Suk Cha *et al.* (6) and Jan Tetsch *et al.* (12), however, even in these studies more complications were associated with lower bone volume.

Smoking

Chyun-Suk Cha *et al.* (6) and Max J. Zinser *et al.* (7) assessed smoking impact on the long-term treatment outcomes (Table 5). It was concluded in both studies that smoking has significantly increased a risk of implant loss. Significantly higher rate of failures has been reported among the smoking patients, as compared to non-smokers. It was discovered that smoking is statistically significant factor making influence on the long-term treatment outcomes.

Age

The study by Max J. Zinser *et al.* (7) examined a correlation between the age of patients and the long-term outcomes of the treatment. The study revealed that significantly higher number of the implants was lost in the group of elderly patients. Age was statistically significant factor influencing the long-term outcomes of the treatment ($p < 0.0042$), (Table 6).

Patrick J. Nolan *et al.* (1) in their study examined relation between the age of patients and the peculiarities of sinus membrane. Analysis of all failures in both age groups has revealed that higher number of failures in the group of the patients of advanced age was associated with the intact, rather than perforated, membranes. Mean incidence of failures associated with perforated membranes was 23.5%. Mean incidence of failures associated with perforated membranes was in the group of younger patients was 42.9%. These findings have indicated that patients with advanced age are exposed to higher risk of complications even if the sinus membranes are intact. Like in the study by Max J. Zinser *et al.* (7), age was statistically significant factor making influence on the long-term outcomes of the treatment ($p = 0.0408$).

Total 1598 OSFE surgery interventions were examined. Mean incidence of successful surgeries in different studies has varied from 96% to 100%. Mean general incidence of success cases was 98.4%. Slightly better results have been reported after the OSFE surgery (98.4%) as compared to the mean general success of LSFE (96.6%), however this was not a significant difference ($p = 0.3130$). Therefore one may conclude that there has not been any difference demonstrated between the long-term treatment outcomes of both treatment methods.

Sinus membrane perforations

The most common complication during the OSFE (as in the LSFE) surgery still remains perforation of sinus membrane. Four studies have been performed in order to examine the influence of sinus membrane perforations on the long-term outcomes of OSFE surgery. All studies came to the same conclusion – irrespective of the frequency of this complication, perforation of sinus membrane has no effect on the long-term outcomes of the treatment (Table 8).

Any differences have been reported in the studies by Xi Ding *et al.* (11) and Schih-Cheng Wen *et al.* (14) between the implants screwed into the intact and perforated membranes. Mean success incidence rates were

Table 5. Smoking influence on the long-term treatment outcomes

Study	Patients (smoking)	Number of implanted implants, n	Lost implants, n	Mean success level, %	p value
Chyun-Suk Cha <i>et al.</i>	Smokers	48	7	85.5	$p = 0.0005$ significant
	Non-smokers.	414	9	97.9	
Max J. Zinser <i>et al.</i>	Smokers	470	47	90	$p < 0.0009$ significant
	Non-smokers.	575	23	96	

Table 6. Impact of age on the long-term treatment outcomes

Study	Patients' age (years)	Number of implanted implants, n	Lost implants, n	Mean success level, %	p value	Failures (bone removal)
In the studies by Max J. Zinser <i>et al.</i>	<60	636	34	94.6	$p < 0.0042$ significant	3 All 3 cases were accompanied by active sinusitis and bone infections
	>60	388	35	90.9		

identical. All 87 implants in the study by Hae-Young Kim *et al.* (13) were intentionally perforated into the sinus membrane. Mean survival of the implants in this study was 100%. All 63 implants in the study by Nasser Nooh (10) were screwed into the perforated membrane. Only one implant was rejected (98.4%).

The use of bone-graft

Recently many studies have been conducted, which proved the absence of any correlation between the long-term success of a surgery and use of bone graft during the OSFE surgery. Mean implant survival rates in this review after the surgeries with or without bone graft was identical. There were total 8 studies of OSFE; three of them involved usage of the bone graft, while the remaining five studies were performed without the use of it. The mean rate of success was 97.8% with bone graft and 98.7% – without bone graft. This was not a statistically significant factor (p=0.7161).

Sinus membrane thickness

The thickness of sinus membrane during LSFE as well as OSFE may influence the long-term treatment outcomes. Schih-Cheng Wen *et al.* (14) assessed the impact of membrane thickness on the development of perforations (Table 9). Rather interesting tendency was discovered: membrane perforation has been more often reported in the patients with very thin or very thick membrane. The lowest risk of perforation was reported in the patient with the sinus membrane of moderate thickness. This was a statistically significant factor (p=0.0011). It has been also found that the most commonly reported thickness of the membrane was <1 mm.

DISCUSSION

Sinus membrane perforations have remained

as the main complication. This factor has been found to be statistically significant in some studies and insignificant in other ones, however the same tendency has been discovered in all LSFE assessments – perforated membrane has been associated with significantly higher number of complications if compared with the intact membrane. It was found that during OSFE intervention, contrary to LSFE, the mean survival rates of the implants both in the perforated and intact membrane was identical.

Inflammatory complications after the LSFE surgery are the sinus membrane inflammation and the infection of bone graft. It was concluded during current studies that both complications may be controlled. Sinusitis or infection of bone graft can develop separately or may be interrelated. Infection of bone graft can be local (limited at the augmentation site) and not necessarily it would spread to the mucous membranes of sinus and cause sinusitis.

The authors have concluded that higher number of failures in case of lower volume of bone could be predetermined by the following reasons: 1) higher

Table 7. Complications of osteotome sinus floor elevation surgery

No.	Study	Year	Study duration (years)	Screwed implants, n	Lost implants, n	Mean success of surgery (%)
1	Stefano Volpe <i>et al.</i>	2013	3	29	-	100
2	Bernardello Fabio <i>et al.</i>	2011	10	134	5	96.3
3	Nasser Nooh	2013	1	63	1	98.4
4	Xi Ding <i>et al.</i>	2013	3	51	-	100
5	Jan Tetsch <i>et al.</i>	2010	15	983	27	97.2
6	Hae-Young Kim <i>et al.</i>	2013	1.5	87	-	100
7	Schih-Cheng Wen <i>et al.</i>	2014	3	185	-	100
8	Giovanni B. Bruschi <i>et al.</i>	2010	16	66	3	95.4
Total:			1-16	1598	36	98.4

Table 8. Influence of membrane perforations on the long-term OSFE treatment outcomes

Study	Membrane condition	Screwed implants, n	Lost implants, n	Mean success level, %
Nasser Nooh	Perforated	63	1	98.4
Hae-Young Kim <i>et al.</i>	Perforated	87	0	100
Xi Ding <i>et al.</i>	Intact	45	0	100
	Perforated	6	0	100
Schih-Cheng Wen <i>et al.</i>	Intact	153	0	100
	Perforated	32	0	100

Table 9. Influence of sinus membrane thickness on the occurrence of perforations

Sinus membrane thickness	Incidence, %	Perforations, %	p value
<1 mm	38.9	18	p=0.0011 significant
<2 mm	35.1	13.8	
>2 mm	25.9	20.8	

deficiency of a bone requires higher mechanical elevation of sinus membrane, consequently requiring bigger volume of a bone graft; 2) it has been suggested that elasticity of sinus membrane is lower in the areas containing less volume of bone; 3) higher level of bone destruction or bone resorption have been usually accompanied by different inflammatory processes; 4) the primary stability of the implant is more difficult to reach if bone volume is low.

Studies of the efficacy of bone graft for OSFE surgery (8, 9, 15) demonstrated that the use of bone graft in such cases is of no benefit. Based on the study data, mean survival of the implants with or without bone grafts were identical. It has also been noted that a bone around the implant apex forms even without a bone graft.

The authors concluded that higher number of complications was associated with thinner or especially thick membrane. This could be explained by the fact that elasticity and durability of the notably thinner membrane is significantly lower. Very thick membrane is usually associated with the inflammatory processes leading to membranes' proliferation or scarring. It has been noticed that sinus membranes

of elderly or smoking patients were less resilient, thinner and had lower regenerative properties.

CONCLUSIONS

1. Sinus membrane perforation during LSFE surgery has significant negative effect on the long-term outcomes of the treatment.
2. Sinus membrane injured during OSFE surgery has no influence on the long-term outcomes of the treatment.
3. Sinusitis or bone infections are controllable complications; they have no significant influence on the long-term outcomes of the treatment.
4. Higher volume of bone has a favourable effect on the long-term outcomes of the treatment.
5. The thickness of sinus membrane reflects the regenerative potential and is important for treatment outcomes.
6. Advanced age and smoking have significant negative impact on the long-term outcomes of the treatment.

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