

Tiziano Testori, Claudio Stacchi, Pietro Felice, Enrico M Strappa, Charlotte Gemelli, Tommaso Clauser, Antonio Rapani, Muhammad H Saleh, Gustavo Avila-Ortiz, Federico Berton, Michael M Bornstein, Daniele Botticelli, Jae-Kook Cha, Hsun-Liang Chan, Roberto Farina, Pablo Galindo-Moreno, Ui-Won Jung, Hyun-Chang Lim, Teresa Lombardi, Thomas Starch-Jensen, Andreas Stavropoulos, Silvio Taschieri, Daniel Thoma, Leonardo Trombelli, Stephen Wallace, Matteo Chiapasco, Ole T Jensen, Jaime Lozada, Michael A Pikos, Roberto Pistilli, Istvan Urban, Pascal Valentini, Francesco Zuffetti, Giovanni Felisati, Alberto Saibene, John R Craig, Hom-Lay Wang

Management of postoperative complications after lateral sinus floor augmentation: A multidisciplinary clinical consensus utilising the Delphi method

KEYWORDS

consensus, maxillary sinusitis, peri-implantitis, sinus floor augmentation

ABSTRACT

Purpose: To achieve a consensus among international experts regarding the management of postoperative complications after maxillary sinus floor elevation.

Materials and methods: A total of 32 experts were enrolled and divided into dental implant providers (21), experts with a well-established reputation as sinus specialists (8), ear, nose and throat specialists (2), and experts with a well-established reputation as ear, nose and throat specialists (1). Before starting, a systematic literature search was conducted on the topic, and a list of articles was sent to the panel. The development group formulated 20 statements, which were sent out in the form of a survey. After each round, the statements upon which a consensus was not reached were reformulated based on anonymous comments from participants. A total of three rounds were planned.

Results: After the third round, a consensus was reached on 15 key statements regarding the management of postoperative complications following sinus floor elevation. Agreement was established on issues including common postoperative symptoms, use of radiographic assessments, the necessity of surgical interventions such as partial or total graft removal, and the potential need for functional endoscopic sinus surgery. Near-consensus was achieved on additional points concerning normal postoperative symptoms, timing of total graft removal and approaches to late graft infections.

Conclusions: The present Delphi consensus suggests that postoperative symptoms such as pain and swelling are generally manageable with appropriate pharmacological treatment. It also outlines conditions where radiographic evaluation is recommended for further assessment. Surgical options, including partial or total graft removal and functional endoscopic sinus surgery, are recommended based on the clinical scenario and response to initial treatments. Variability in practices, particularly regarding antibiotic use and specific intervention timing, suggests a need for further research to be conducted in order to standardise treatment protocols and address gaps in evidence.

Conflict-of-interest statement: *The authors declare there are no conflicts of interest relating to this study.*

Introduction

Lateral sinus floor elevation (LSFE) is a widely documented and predictable clinical procedure for the rehabilitation of the atrophic posterior maxilla.^{1,2} Following tooth extraction, the resulting alveolar ridge resorption and pneumatisation of the maxillary sinus can hinder dental implant placement. The management of the patient undergoing this surgical procedure may require a multidisciplinary approach.³ The field of expertise is shared by experts in implant dentistry and ear, nose and throat (ENT) specialists.⁴ Close collaboration can be beneficial for both pre-surgical assessment and the management of postoperative complications of LSFE.⁵

Data from the most recent literature reveal a relatively low rate of postoperative complications after LSFE.⁶⁻⁸ In a retrospective study, Schwarz et al⁹ reported an incidence of postoperative sinusitis of 8.6% in a sample of 300 patients and 407 surgical procedures. Some studies have suggested an increased incidence of postoperative complications in the presence of sinus membrane perforation. Nolan et al¹⁰ reported a higher incidence of postoperative sinusitis after membrane perforation (11.3%) compared to in sinuses without perforations (1.4%). In a total of 359 sinus lift surgeries, the authors also observed an incidence of graft infections of 6.7%, among which 70.8% were in the sinus perforation group.¹⁰ Similarly, Krennmair et al¹¹ described a higher prevalence of postoperative sinusitis and graft infections in sinuses with membrane perforation (9.7% and 6.8%, respectively) compared to sinuses without perforation (1.2% and 0.3%, respectively). Fischer et al¹² also reported that acute and chronic rhinosinusitis are potential complications of LSFE, occurring more frequently in patients with preexisting sinus disease, anatomical sinonasal obstructions or intraoperative perforations of the sinus membrane. Finally, Moreno Vazquez et al¹³ observed a dispersion of the graft in the maxillary antrum in 2 out of 202 consecutively treated cases (incidence of 1.6%).

The management of postoperative complications following LSFE has been a topic of ongoing debate in the literature.^{13,14} Several studies have addressed this issue, but a comprehensive solution

remains elusive. A recent systematic review by Schlund et al¹⁵ concluded that it is difficult to establish an optimal treatment protocol for sinus graft infections due to the considerable variability in how complications are managed across different studies, combined with the generally low level of supporting evidence. In response to this uncertainty, Testori et al¹⁶ recently published a clinical consensus offering practical guidelines on the subject. Building on these efforts, the present Delphi consensus seeks to establish an updated, internationally recognised and multidisciplinary agreement on the management of postoperative complications after LSFE that refines and expands upon the recommendations previously described.

Materials and methods

The present clinical consensus statement (CCS) was developed following the methodology described by Rosenfeld et al¹⁷ and later modified by Testori et al.^{18,19} Once it had been determined that the management of postoperative complications after LSFE was an appropriate topic for a CCS, several experts from relevant disciplines, namely implantologists, maxillofacial surgeons and ENT specialists, were recruited. The inclusion of diverse disciplines ensured a thorough and comprehensive discussion of the topic. The inclusion criteria for expert selection were as follows:

- the first 15 authors listed on www.expertscape.com as of 19 February 2024 for the topic “sinus floor augmentation”;
- the first 15 authors listed on www.expertscape.com as of 19 February 2024 for the topic “maxillary sinus” (excluding those already listed under “sinus floor augmentation”);
- h-index greater than 15 (according to www.scopus.com, accessed on 19 February 2024).

Expertscape is an independent company that uses data from the National Institutes of Health database (PubMed.gov) to identify and objectively rank researchers as experts on specific topics based on the quantity and type of scientific articles they have published over the past 10 years.

Table 1 Authors enrolled for the clinical consensus

Role	Expert
Dental implant providers	AVILA-ORTIZ, Gustavo
	BERTON, Federico
	BORNSTEIN, Michael
	BOTTICELLI, Daniele
	CHA, Jae-Kook
	CHAN, Hsun-Liang
	FARINA, Roberto
	FELICE, Pietro
	GALINDO-MORENO, Pablo
	JUNG, Ui-Won
	LIM, Hyun-Chang
	LOMBARDI, Teresa
	MORDENFELD, Arne
	STACCHI, Claudio
	STARCH-JENSEN, Thomas
	STAVROPOULOS, Andreas
	TASCHIERI, Silvio
	TESTORI, Tiziano
Experts with a well-established reputation as a maxillary sinus specialist	THOMA, Daniel
	TROMBELLI, Leonardo
	WALLACE, Stephen
	CHIAPASCO, Matteo
	JENSEN, Ole
	LOZADA, Jaime
	PIKOS, Micheal A
	PISTILLI, Roberto
	URBAN, Istvan
	VALENTINI, Pascal
ENT specialists	WANG, Hom-Lay
	ZUFFETTI, Francesco
	FELISATI, Giovanni
Experts with a well-established reputation as an ENT specialist	SAIBENE, Alberto
	CRAIG, John R

Experts were excluded if their contributions to research were not strictly clinical with respect to LSFE (e.g., statisticians, anatomists, histologists, ENT specialists focusing on other maxillary sinus conditions). In addition, the development group (described in more detail later) identified several other experts who were not selected based on the criteria outlined above but are internationally recognised for their long-standing contributions to LSFE research and clinical practice.

Table 2 List of chairmen

Name and qualification suffix(es)	Affiliation(s)
Tiziano Testori, MD, DDS, MSc, FICD	Head, IRCCS Galeazzi-Sant'Ambrogio Hospital, Section of Implant Dentistry, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy; Adjunct Clinical Associate Professor, Department of Periodontics and Oral Medicine, University of Michigan, School of Dentistry, Ann Arbor, MI, USA; Lecturer, Harvard School of Dental Medicine, Boston, MA, USA
Claudio Stacchi, DDS, MSc	Adjunct Professor, Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy; Private practice, Gorizia, Italy
Pietro Felice, DDS, MD, PhD	Associate Professor, Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy
Hom-Lay Wang, DDS, MSD, PhD	Full Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA

Table 3 List of assistant chairs

Name and qualification suffix(es)	Affiliation(s)
Enrico M Strappa, DDS, MSc	Resident, Section of Implantology and Oral Rehabilitation, Dental Clinic, IRCCS Galeazzi Sant'Ambrogio Hospital, Milan, Italy; Resident, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy
Charlotte Gemelli, DDS	Resident, Postgraduate Programme in Implant and Bone Reconstructive Surgery, University of Bologna, Bologna, Italy
Tommaso Clauser, DDS, MSc	Adjunct Professor, Research Unit in Periodontology and Periodontal Medicine, Department of Experimental and Clinical Medicine, University of Florence, Florence, Italy
Antonio Rapani, DDS, MSc	Lecturer, Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy
Muhammad H Saleh, BDS, MSD, MS	Clinical Assistant Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA

The selected experts were contacted via email and invited to participate in the CCS. Table 1 provides a detailed list of those who accepted the invitation. All experts confirmed that they had no conflicts of interest.

The development group consisted of four chairmen (TT, CS, PF and HLW), who led the group, and five assistant chairs (EMS, CG, TC, AR and MS) who were responsible for sending and collecting data to and from each participant enrolled in the CCS (Tables 2 and 3). A systematic literature search was conducted to provide background on the most recent scientific evidence related to the topic, as previously outlined by Testori et al.¹⁸

Systematic literature search

A systematic literature search was conducted via MEDLINE (via PubMed). The search algorithm was (“maxillary sinus”[MeSH Terms] OR (“maxillary”[All Fields] AND “sinus”[All Fields]) OR “maxillary sinus”[All Fields] OR (“paranasal sinuses”[MeSH Terms] OR (“paranasal”[All Fields] AND “sinuses”[All Fields]) OR “paranasal sinuses”[All Fields] OR “sinus”[All Fields] OR “sinus s”[All Fields]) AND (“floor s”[All Fields] OR “floored”[All Fields] OR “floorings”[All Fields] OR “floors and floorcoverings”[MeSH Terms] OR (“floors”[All Fields] AND “floorcoverings”[All Fields]) OR “floors and floorcoverings”[All Fields] OR “floor”[All Fields] OR “flooring”[All Fields] OR “floors”[All Fields]) AND (“elevate”[All Fields] OR “elevated”[All Fields] OR “elevates”[All Fields] OR “elevating”[All Fields] OR “elevation”[All Fields] OR “elevational”[All Fields] OR “elevations”[All Fields])) OR (“paranasal sinuses”[MeSH Terms] OR (“paranasal”[All Fields] AND “sinuses”[All Fields]) OR “paranasal sinuses”[All Fields] OR “sinus”[All Fields] OR “sinus s”[All Fields])

AND (“lifting”[MeSH Terms] OR “lifting”[All Fields] OR “lift”[All Fields])) AND (“postoperative complications”[MeSH Terms] OR “complication”[All Fields] AND “postoperative”[All Fields] OR “complications”[All Fields] AND “postoperative”[All Fields])).

The inclusion criteria were:

- original articles in English published in peer-reviewed journals;
- studies published from 1 January 2012 to 31 December 2023;
- literature reviews (systematic reviews, narrative reviews, meta-analyses);
- clinical practice guidelines.

The exclusion criteria were:

- studies for which the full text was not available;
- studies that adopted a transcrestal surgical approach;
- studies on zygomatic and pterygoid implants.

An additional manual search was carried out of the leading journals within the field (International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Forum of Allergy & Rhinology and American Journal of Rhinology & Allergy). All the details concerning the manual search are included in Appendix 1 and 2 (available at <http://ijoi.quintessenz.de>). Figure 1 shows the selection process for the studies, which are listed in Table 4.

Clinical consensus statements

The chairmen and their assistants drafted the statements, specifically targeting specialists in the relevant fields. These statements were developed based on the findings from the systematic literature search.

Survey process with the Delphi method

Surveys were sent to the selected experts using Google Forms. Random codes were generated and assigned to each participant to ensure anonymity. Each participant expressed their opinion on a 9-point Likert scale, where 1 meant “strongly disagree”, 3 “disagree”, 5 “neutral”, 7 “agree” and 9 “strongly agree”. After each round, the overall level

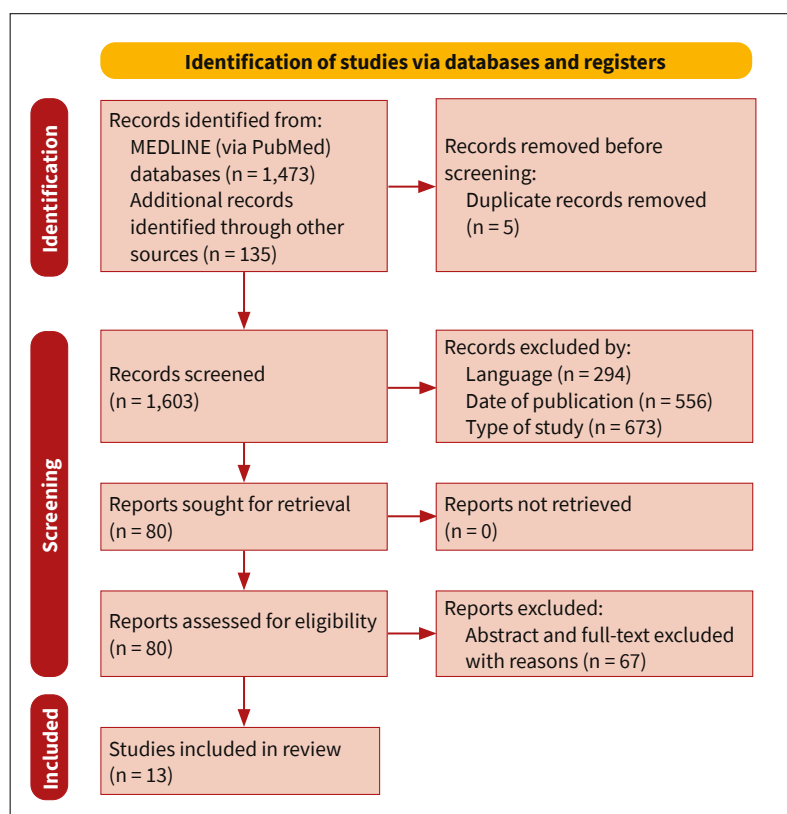


Fig 1 Flowchart for study selection based on the inclusion and exclusion criteria.

Table 4 Studies included in the systematic literature search using the parameters described by Rosenfeld et al¹⁷

Author(s)	Title	Year of publication	Journal
Craig et al ²⁰	Management of odontogenic sinusitis: Multidisciplinary consensus statement	2020	International Forum of Allergy & Rhinology
Felisati et al ²¹	Sinonasal complications resulting from dental treatment: Outcome-oriented proposal of classification and surgical protocol	2013	American Journal of Rhinology & Allergy
Amid et al ²²	Effect of Schneiderian membrane thickening on the maxillary sinus augmentation and implantation outcomes: A systematic review	2021	Journal of Maxillofacial and Oral Surgery
Valentini ²³	How to prevent and manage postoperative complications in maxillary sinus augmentation using the lateral approach: A review	2023	International Journal of Oral and Maxillofacial Implants
Allevi et al ²⁴	Diagnostic criteria for odontogenic sinusitis: A systematic review	2021	American Journal of Rhinology & Allergy
Allevi et al ²⁵	Treatment of sinusitis following dental implantation: A systematic review and meta-analysis	2022	American Journal of Rhinology & Allergy
Salgado-Peralvo et al ²⁶	Preventive antibiotic therapy in sinus elevation procedures: A systematic review	2023	International Journal of Oral and Maxillofacial Implants
Niederquell et al ²⁷	Bilateral postoperative cyst after maxillary sinus surgery: Report of a case and systematic review of the literature	2016	Case Reports in Dentistry
Fugazzotto et al ²⁸	Complications when augmenting the posterior maxilla	2015	Dental Clinics of North America
Schlund et al ¹⁵	Management of sinus graft infection-a systematic review	2022	International Journal of Oral and Maxillofacial Surgery
Kim et al ²⁹	A review of complications of maxillary sinus augmentation and available treatment methods	2019	Journal of the Korean Association of Oral and Maxillofacial Surgery
Hsu et al ³⁰	Complications of sinus floor elevation procedure and management strategies: A systematic review	2022	Clinical Implant Dentistry and Related Research
Testori et al ³¹	How to avoid intraoperative and postoperative complications in maxillary sinus elevation	2023	Periodontology 2000

of agreement was assessed for every item based on the mean score. An outlier was defined as a value outside the mean score by ± 2 Likert points. Threshold values were established a priori to define the following outcomes:

- Consensus: mean score ≥ 7 with at most one outlier;
- Near consensus: mean score ≥ 6.5 with no more than two outliers;
- No consensus: statements not meeting the criteria for “consensus” or “near-consensus”.

Participants were given the opportunity to provide anonymous comments, which were mandatory in case of disagreement and optional in the event of agreement (score ≥ 6). The comments for each statement were used by the development group to revise those upon which a consensus was yet to be reached, then, once rephrased, the updated statements were resubmitted to the experts for the next round. Before starting the Delphi process, it was established that there would be a maximum of

three rounds. Finally, a qualitative analysis was conducted based on the results obtained.

Data analysis

The assistant chairs collected the anonymised data and comments and calculated the agreement score for each statement. After each round, a report of consensus level, number of outliers, mean and median score was formulated using RStudio (RStudio Team, Boston, MA, USA).

Results

After the first round, a consensus had been reached for three statements. The 17 statements upon which no consensus was reached were rephrased following the anonymous suggestions made by the participants, then, at the end of the second round, a consensus was found to have been reached on a further six statements. Eleven statements were

rephrased for the third and final round, after which a consensus was achieved for a further seven statements. Near-consensus was reached for four statements, whereas no consensus was obtained for one statement. The final mean and median agreement and the number of outliers for every statement are reported in Table 5. By the end of the third round, a consensus had been reached for the following fifteen statements:

- Statement #1: Postoperative signs and symptoms may include oedema, ecchymosis, epistaxis, discomfort, tenderness and pain.
- Statement #3: When swelling persists or worsens alongside escalating pain, fever or a foul odour and taste, even when on adequate antibiotic treatment, radiographic assessment may be advantageous.
- Statement #4: For patients with suspected sinusitis, CBCT may be useful in evaluating their clinical situation.
- Statement #5: If the surgeon does not have the competence and clinical experience to deal with postoperative complications, it is advisable to refer the patient, since it is preferable to detect complications as early as possible.
- Statement #6: Before considering total or partial graft removal, pharmacological treatment should be the first course of action in cases with mild symptoms without systemic involvement.
- Statement #8: In selected cases, expert surgeons could opt for partial instead of total graft removal. However, since there is no robust evidence on the topic, the procedure should be regarded as empirical and based on the individual clinical scenario due to the lack of objective measures confirming residual infection.
- Statement #9: Surgical intervention should become necessary when pharmacological therapy alone does not initially resolve dental implant-related sinusitis.
- Statement #11: Functional endoscopic sinus surgery (FESS) may be indicated after both adequate pharmacological treatment and intraoral surgical graft removal have been unsuccessful in resolving sinusitis.
- Statement #12: Should graft material loss within the sinus cavity block the ostiomeatal complex (OMC), especially when anatomical variations are present, its complete surgical removal may be necessary.
- Statement #14: Total dislocation of the implant into the sinus necessitates surgical retrieval.
- Statement #15: Obliteration of the sinus antrum by overfilling may require secondary surgery to remove the excess graft.
- Statement #16: The presence of mucosal thickening over the implant or the graft is not necessarily a sign of failure.

Table 5 Final mean and median agreement and number of outliers for each statement

#	Statement	Mean agreement	Median agreement	Number of outliers	Consensus?	Last round of appearance
1	Postoperative signs and symptoms may include oedema, ecchymosis, epistaxis, discomfort, tenderness and pain.	8.333333	9.0	1	Yes	1
2	Normal postoperative symptoms (dull pain) that could be controlled by analgesic consumption and signs of minor swelling (intra- and/or extraoral), minor ecchymosis and minor nose bleeding, should disappear within the first week. In a limited number of patients, experiencing pain only upon pressure, not spontaneously, for up to 3 weeks postoperatively could be regarded as normal.	7.633333	7.5	2	Near-consensus	3
3	When swelling persists or worsens alongside escalating pain, fever or a foul odour and taste, even when on adequate antibiotic treatment, radiographic assessment may be advantageous.	8.03125	8	1	Yes	2
4	For patients with suspected sinusitis, CBCT may be useful in evaluating their clinical situation.	8.34375	9	0	Yes	2

#	Statement	Mean agreement	Median agreement	Number of outliers	Consensus?	Last round of appearance
5	If the surgeon does not have the competence and clinical experience to deal with postoperative complications, it is advisable to refer the patient, since it is preferable to detect complications as early as possible.	8.733333	9	0	Yes	3
6	Before considering total or partial graft removal, pharmacological treatment should be the first course of action in cases with mild symptoms without systemic involvement.	8.233333	8.5	0	Yes	3
7	In cases of graft infection, with or without associated sinusitis, pharmacological treatment may include amoxicillin with clavulanic acid, with or without metronidazole, depending on the clinical situation. For those allergic to penicillin, one of the most prescribed alternatives is levofloxacin, but the type of antibiotics and regimen vary from country to country.	7.7	8.0	3	No	3
8	In selected cases, expert surgeons could opt for partial instead of total graft removal. However, since there is no robust evidence on the topic, the procedure should be regarded as empirical and based on the individual clinical scenario due to the lack of objective measures confirming residual infection.	7.8	8	1	Yes	3
9	Surgical intervention should become necessary when pharmacological therapy alone does not initially resolve dental implant-related sinusitis.	8.366667	9	0	Yes	3
10	If symptoms of sinusitis continue despite partial graft removal having been performed and medical treatment having been administered, the surgeon should opt to perform total intraoral graft removal with or without FESS. The timing of FESS (simultaneous to graft removal or delayed) depends on different factors, such as the clinical scenario and the surgeon's level of experience.	8	9	2	Near-consensus	3
11	FESS may be indicated after both adequate pharmacological treatment and intraoral surgical graft removal have been unsuccessful in resolving sinusitis.	8.0625	8.5	1	Yes	2
12	Should graft material loss within the sinus cavity block the OMC, especially when anatomical variations are present, its complete surgical removal may be necessary.	8.28125	9	1	Yes	2
13	Even if there is no robust evidence but only case reports, for late graft infections due to peri-implantitis, years after the sinus elevation procedure, thorough debridement of the lesion without removing the surrounding mineralised tissue could be an alternative to complete graft and implant removal.	7.5	7	2	Near-consensus	3
14	Total dislocation of the implant into the sinus necessitates surgical retrieval.	8.625	9	0	Yes	2
15	Obliteration of the sinus antrum by overfilling may require secondary surgery to remove the excess graft.	8.0	8.0	1	Yes	2
16	The presence of mucosal thickening over the implant or the graft is not necessarily a sign of failure.	8.272727	9	1	Yes	1
17	Non-osseointegrated implants may act as infection focal points and their removal could be considered in the prevention of sinus-related pathology.	8.363636	9	1	Yes	1
18	In cases of treatable peri-implantitis not involving the sinus (in which the extent of bone loss does not reach the sinus antrum), implant removal may be avoided.	8.033333	8.5	2	Near-consensus	3
19	Severe peri-implantitis causing oroantral communication or fistula may require dental implant removal.	8.666667	9	0	Yes	3
20	An efficient implant maintenance programme is essential to achieve long-term success.	8.766667	9	0	Yes	3

- Statement #17: Non-osseointegrated implants may act as infection focal points and their removal could be considered in the prevention for sinus related pathology.
- Statement #19: Severe peri-implantitis causing oroantral communication or fistula may require dental implant removal.
- Statement #20: An efficient implant maintenance programme is essential to achieve long-term success.

A near-consensus was achieved on the following four statements:

- Statement #2: Normal postoperative symptoms (dull pain) that could be controlled by analgesic consumption and signs of minor swelling (intra- and/or extraoral), minor ecchymosis and minor nose bleeding, should disappear within the first week. In a limited number of patients, experiencing pain only upon pressure, not spontaneously, for up to 3 weeks postoperatively could be regarded as normal.
- Statement #10: If symptoms of sinusitis continue despite partial graft removal having been performed and medical treatment having been administered, the surgeon should opt to perform total intraoral graft removal with or without FESS. The timing of FESS (simultaneous to graft removal or delayed) depends on different factors, such as the clinical scenario and the surgeon's level of experience.
- Statement #13: Even if there is no robust evidence but only case reports, for late graft infections due to peri-implantitis, years after the sinus elevation procedure, thorough debridement of the lesion without removing the surrounding mineralised tissue could be an alternative to complete graft and implant removal.
- Statement #18: In cases of treatable peri-implantitis not involving the sinus (in which the extent of bone loss does not reach the sinus antrum), implant removal could be avoided.

No consensus was reached for the following statement:

- Statement #7: In cases of graft infection, with or without associated sinusitis, pharmacological

treatment may include amoxicillin with clavulanic acid, with or without metronidazole, depending on the clinical situation. For those allergic to penicillin, one of the most prescribed alternatives is levofloxacin, but the type of antibiotics and regimen vary from country to country.

Discussion

The present clinical consensus was performed using a modified Delphi consensus process, as previously described by Rosenfeld et al¹⁷ and later revised by Testori et al.^{18,19} Participants were asked to share their expertise on identifying complications associated with LSFE, graft infection, peri-implantitis on implants positioned after LSFE, implant dislocation in the sinus, graft overfilling, mucosal thickening, insertion of non-osseointegrated implants in augmented sinuses, and implant maintenance. The consensus rules were designed for fewer participants, which made reaching a consensus more challenging. Nevertheless, a consensus or near-consensus was achieved for all but one of the statements.

The panel of experts agreed on the statement regarding postoperative signs and symptoms after LSFE (#1). A near consensus was reached on the duration of postoperative symptoms (#2). This is an important parameter to identify the onset of a postoperative complication after LSFE in early stages (#3 and #4). Most studies use a VAS and patient-reported outcome measures (PROMs) to describe postsurgical morbidity. In a randomised clinical trial, Taschieri et al³² observed that in most cases, postoperative pain and swelling following LSFE were almost resolved after 7 days. In an observational study, Rengo et al⁸ found that the peak of pain occurred within the first 2 postoperative days, whereas swelling and ecchymosis persisted for up to 4.09 ± 1.43 and 2.21 ± 2.31 days, respectively. These results are consistent with those reported by Del Fabbro et al³³ and Farina et al,³⁴ who found that patients' intake of painkillers (ibuprofen 600 mg) gradually decreased as symptoms subsided progressively. Gaspar et al³⁵ reported that, in addition to ibuprofen 600 mg, paracetamol 1,000 mg was used to manage pain peaks. The choice of painkiller varied across

studies, reflecting the preference of the different clinicians. Previously, Testori et al¹⁶ reported an initial recovery period of up to 3 weeks following LSFE. The findings of the present CCS suggest that postoperative symptoms resolve more quickly in most cases. This improvement may be attributed to advances in surgical techniques, careful patient selection during the preoperative phase and a reduced incidence of intraoperative complications.^{30,36}

Graft infection was a major concern in many of the statements. Although it is not the most frequent complication,^{1,37} its potential to lead to graft failure makes it a critical issue.³⁸ A recent analysis by Schlund et al¹⁵ highlighted that treatment protocols for graft infection vary widely between studies, indicating a lack of standardised approaches. Typically, graft infections are linked with the development of maxillary sinusitis, leading to the simultaneous occurrence of these conditions. This association underscores the importance of addressing both issues in order to manage postoperative care effectively. In the present CCS, participants agreed that in the presence of graft infection, pharmacological treatment should be attempted before surgery (#6); however, no consensus was reached on the antibiotic of choice (#7) despite the high rate of median and mean agreement. Near-consensus was not achieved for only one outlier. Thus, 29 experts out of 32 (90%) agreed with statement #7. The main problem was finding an alternative solution for patients allergic to penicillin. The outliers recommended ciprofloxacin or, less specifically, quinolones instead of levofloxacin. The authors also recommended displaying caution due to the side effects caused by quinolones. One author, despite agreeing with the statement, recommended azithromycin. Testori et al¹⁶ advocated the use of a combination of amoxicillin and clavulanic acid with metronidazole in most cases, whereas levofloxacin was suggested for allergic patients. Additionally, during the development of the current CCS, it was determined that amoxicillin and clavulanic acid, either alone or in combination with metronidazole, is considered the antibiotic of choice. A weaker consensus was reached regarding the use of levofloxacin for patients allergic to penicillin. Administration of clindamycin was strongly discouraged by the experts due to its side effects.

These findings align with the current literature, which recommends amino-penicillins due to their broad spectrum of action.³⁹ Recently, Saibene et al⁴⁰ performed a microbiological analysis of specimens from odontogenic sinusitis or, more precisely, sino-nasal complications of dental disease or treatment (SCDDT).²¹ This type of sinusitis also includes those caused by graft infection after LSFE, peri-implantitis or dislocation of an implant in the maxillary sinus. The authors found a clear predominance of bacteria of the *Staphylococci* species, most of which were able to produce beta-lactamase.⁴⁰ This may explain the reduced sensitivity of cultures to amoxicillin associated with clavulanic acid compared to levofloxacin, teicoplanin and vancomycin. In a subsequent prospective study, the same research group validated levofloxacin as the drug of choice for prophylaxis and post-surgical treatment of patients undergoing endoscopic surgery for SCDDT. In allergic patients, the authors prescribed cefuroxime axetil.⁴¹ Nevertheless, it should be noted that antibiotic therapy is relatively heterogeneous, according to a recent systematic review of the literature.¹⁵ This reflects the differences between countries and may explain the lack of consensus obtained in the present study on this topic (statement #7).

Medical treatment alone is often insufficient to resolve graft infection²⁰; thus, surgery may be necessary for complete resolution of the clinical scenario (statement #9). In the rounds of this consensus, partial graft removal was recommended as the treatment of choice if pharmacological therapy fails to resolve graft infection, supported by evidence from recent studies.^{42,43} Some participants noted, however, that the evidence available on this topic is limited and that the appropriate extent of graft removal remains unclear. As a result, the statement was revised to address these concerns (statement #8).

Partial graft removal is considered a conservative procedure that may reduce the need for a more extensive second re-entry. The present authors tried to establish whether a more conservative approach should be attempted as the first line of action, and consensus was achieved (statement #8); however, this is highly operator dependent. In the absence of objective measures, residual infection may persist, potentially leading to recurrence and necessitating

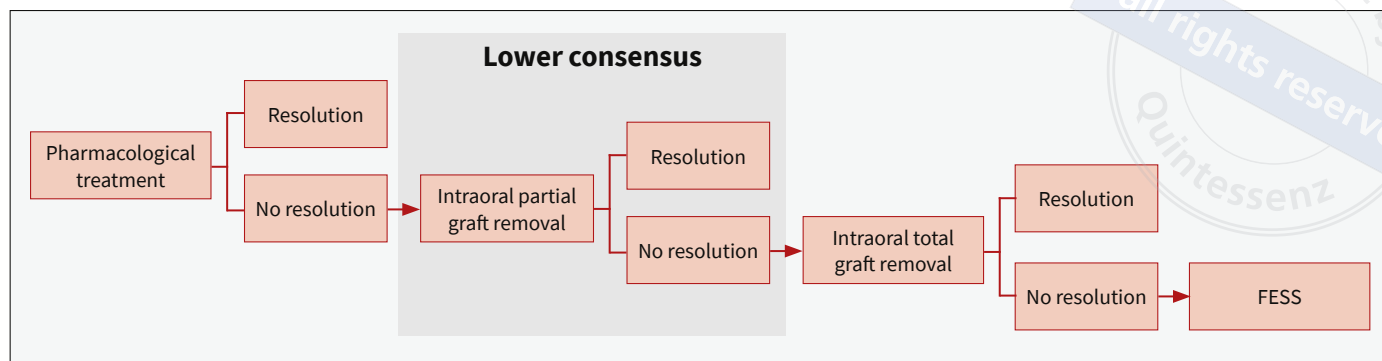


Fig 2 Decision-making algorithm for sinus graft infection management.

a second surgery for complete biomaterial removal. For this reason, several studies suggest total graft removal in the early stages,²⁵ and this was also recommended by a number of experts in the present CCS. Urban et al⁴² specified that partial removal can only be considered when there is no direct communication between the infected graft and the sinus antrum. In such circumstances, a more aggressive approach is indicated.

According to this CCS, graft removal, whether partial or total, should be performed using an intraoral approach as the first choice (statements #10 and #11). FESS is indicated in cases where intraoral graft removal has not been effective previously (statement #11). In case the OMC is blocked, complete surgical removal of the graft should be performed (statement #12).

Although several studies seem to indicate that FESS is more efficient,^{21,44} intraoral graft removal can be considered an effective therapeutic solution in many cases.⁴³ This method, in addition to being less invasive, can reduce the amount of time needed for subsequent surgical re-entry; however, the success of this approach is limited to clinical scenarios where the issue is not external to the sub-antral space (for example, postoperative mucosal thickening causing a blockage of the meatal ostium) but rather related to graft infection. Therefore, a simplified decision tree for graft infection management according to this clinical consensus statement was developed (Fig 2).

In a retrospective study, Pons et al⁴⁵ showed that maxillary sinus health may be correlated with peri-implant disease. In particular, the authors observed that in the presence of infection, significant thickening of the sinus membrane > 2 mm is very likely to be

found compared to in healthy sites (81.1% vs 37.5%, $P < 0.001$).⁴⁵ After effective surgical treatment, the thickness of the membrane may decrease (from 81.1% to 29.7%, $P < 0.001$). Therefore, it is possible to hypothesise that microorganisms associated with peri-implant disease may spread through the grafted area to the sinus membrane. Treatment of this condition must be punctual to preserve not only the implant and the graft, but also maxillary sinus health.^{46,47} Through a multivariate logistic regression, Stacchi et al⁴⁸ identified LSFE (odds ratio [OR] 10.207, 95% confidence interval [CI] 2.28 to 45.70, $P = 0.002$) and the one-stage procedure (OR 11.271, 95% CI 2.39 to 53.18; $P = 0.002$) as risk indicators for peri-implant disease.

In the presence of peri-implantitis around implants at regenerated sites with LSFE, the panel of experts agreed that dental implant removal is not always indicated, in particular when the extent of bone loss is limited (statement #18). This result is in line with what was previously described in a recent consensus¹⁸; however, in cases where peri-implantitis induces severe bone loss, the formation of a fistula or an oroantral communication, a more aggressive approach is indicated (statement #19).

In cases of late graft infection due to peri-implantitis, a near-consensus was reached for a conservative approach (site debridement) rather than an aggressive one (total removal of the graft and dental implant) (statement #13). A reasonable explanation for this could be the lack of scientific evidence on the topic²³; indeed, this type of approach has only been described in a few studies.⁴⁹ Scarano et al⁵⁰ previously showed that infection related to peri-implantitis often compromises the health of

the entire graft and, consequently, of the maxillary sinus. Thus, they recommended total removal, similar to other studies.^{21,51}

Full consensus was reached for dental implant removal in the case of non-osseointegrated implants (statement #17) or total implant dislocation in the sinus (statement #14). The experts agreed that thickening of the membrane above the graft or the implant apex does not necessarily imply a pathological condition (statement #16). This data is in line with a previous consensus¹⁸ and a recent systematic review.⁵²

Maxillary sinus obliteration caused by graft overfilling is an uncommon complication²⁸; however, this condition can alter the physiology of mucociliary clearance, predisposing to the onset of chronic sinusitis.¹⁴ A full consensus was reached that a second surgery to remove the excess graft is necessary in such cases (statement #15).

The panel of experts agreed that an efficient implant maintenance programme is essential to achieve long-term success (statement #20). The maintenance care protocol should be determined individually and a baseline condition identified,⁵³ and the recall frequency must have a specific periodicity. The most recent evidence suggests that the recall frequency should be personalised based on the patient's risk profile.⁵⁴ The statement was also initially formulated to identify postoperative complications clinically and radiographically after sinus floor elevation in the early stages.⁵⁵⁻⁵⁷ This approach would prevent the worsening of the condition and, consequently, further damage.

The present CCS has some limitations. The management of postoperative complications is a topic of ongoing debate in the literature, with considerable variability in treatment protocols.¹⁵ As a result, clinical decisions are frequently guided by expert opinions or individual practitioner preferences. This CCS sought to achieve consensus among experts despite these differing approaches; however, the level of evidence supporting these clinical recommendations is low, so they should not be regarded as definitive guidelines. Additionally, there is a temporal limitation: future research and emerging evidence may lead to changes in treatment strategies, especially given the rising issue of antibiotic resistance, which could impact medical therapy.⁵⁸

Conclusion

Regarding the diagnosis and treatment of postoperative complications of maxillary sinus augmentation, the following conclusions can be drawn:

- postoperative signs and symptoms may include oedema, ecchymosis, epistaxis, discomfort, tenderness and pain;
- normal postoperative symptoms (dull pain) that could be controlled by analgesic consumption and signs of minor swelling (intra- and/or extraoral), minor ecchymosis and minor nose bleeding should disappear within the first week;
- in a limited number of patients, experiencing pain only when pressure is applied, and not spontaneous pain, for up to 3 weeks postoperatively can be considered normal;
- when swelling persists or worsens alongside escalating pain, fever or a foul odour and taste (even when on adequate antibiotic treatment), a radiographic assessment may be advantageous;
- for patients with suspected sinusitis, CBCT may be useful in evaluating their clinical situation;
- if the surgeon does not have the competence and the clinical experience to deal with postoperative complications, it is advisable to refer the patient to an expert with the necessary experience since it is preferable to detect and treat complications as early as possible;
- before considering total or partial graft removal, pharmacological treatment should be the first course of action in cases with mild symptoms without systemic involvement;
- no consensus was reached on the specific type of antibiotics and regimen, which vary from country to country;
- as proposed in previous studies, the use of amoxicillin with clavulanic acid (1 g t.i.d), with or without metronidazole (500 mg t.i.d) seems reasonable, or in allergic patients, levofloxacin (500 mg b.i.d) or moxifloxacin (400 mg b.i.d);
- in selected cases, expert surgeons could opt for partial graft removal. However, since there is no robust evidence on the topic, the procedure should be regarded as empirical and based on the individual clinical scenario due to the lack of objective measures confirming residual infection;

- if symptoms of sinusitis continue despite partial graft removal and medical treatment, the surgeon should opt for total intraoral graft removal with or without FESS;
- FESS may be indicated after both adequate pharmacological treatment and intraoral surgical graft removal have been unsuccessful at resolving sinusitis;
- if graft material dispersed within the sinus cavity blocks the OMC, especially when anatomical variations are present, its complete surgical removal may be necessary;
- even if there is no robust evidence for late graft infection due to peri-implantitis, years after the sinus elevation procedure, thorough debridement of the lesion without removing the surrounding mineralised tissue could be an alternative to complete graft and implant removal;
- in cases of treatable peri-implantitis not involving the sinus (in which the extent of bone loss does not reach the sinus antrum), implant removal may be avoided;
- non-osseointegrated implants may act as infection focal points and their removal could be considered in the prevention of sinus pathologies;
- severe peri-implantitis causing oroantral communication or fistula may require dental implant removal.

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Tiziano Testori

Tiziano Testori, DMD, DDS, MSc, FICD

Head, IRCCS Galeazzi-Sant'Ambrogio Hospital, Section of Implant Dentistry, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy; Adjunct Clinical Associate Professor, Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, MI, USA; Lecturer, Harvard School of Dental Medicine, Boston, MA, USA

Claudio Stacchi, DDS, MSc

Adjunct Professor, Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy; Private practice, Gorizia, Italy

Pietro Felice, DDS, MD, PhD

Associate Professor, Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy

Enrico M Strappa, DDS, MSc

Resident, Section of Implantology and Oral Rehabilitation, Dental Clinic, IRCCS Galeazzi Sant'Ambrogio Hospital, Milan, Italy; Resident, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy

Charlotte Gemelli, DDS

Resident, Postgraduate Programme in Implant and Bone Reconstructive Surgery, University of Bologna, Italy

Tommaso Clauser, DDS, MSc

Adjunct Professor, Research Unit in Periodontology and Periodontal Medicine, Department of Experimental and Clinical Medicine, University of Florence, Florence, Italy

Antonio Rapani, DDS, MSc

Lecturer, Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy

Muhammad H Saleh, BDS, MSD, MS

Clinical Assistant Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA

Gustavo Avila-Ortiz, DDS, MS, PhD

Visiting Professor, Division of Periodontics, Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine, Boston, MA, USA

Federico Berton, DDS, MSc, PhD

Associate Professor, Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy

Michael M Bornstein, Prof Dr med dent

Full Professor and Head, Department of Oral Health & Medicine, University Center for Dental Medicine Basel UZB, University of Basel, Basel, Switzerland

Daniele Botticelli, MD, PhD

Scientific Director, ARDEC Academy, Rimini, Italy

Jae-Kook Cha, DDS, MS, PhD

Associate Professor, Department of Periodontology, College of Dentistry, Research Institute for Periodontal

Regeneration, Yonsei University, Seoul, South Korea; Visiting Associate Professor, Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine, Boston, MA, USA

Hsun-Liang Chan, DDS, MS

Associate Professor, Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, MI, USA

Roberto Farina, DDS, MSD, PhD

Associate Professor and Chair of Oral Surgery, University of Ferrara, Italy

Pablo Galindo-Moreno, DDS, PhD

Full Professor, Department of Oral Surgery and Implant Dentistry, School of Dentistry, University of Granada, Granada, Spain

Ui-Won Jung, DDS, PhD

Professor, Department of Periodontology, Research Institute for Periodontal Regeneration, Yonsei University College of Dentistry, Seoul, South Korea

Hyun-Chang Lim, DDS, PhD

Associate Professor, Department of Periodontology, Kyung Hee University, College of Dentistry, Periodontal Implant Clinical Research Institute, Kyung Hee University Medical Center, Seoul, South Korea

Teresa Lombardi, DDS

Adjunct Professor, Department of Health Sciences, Magna Graecia University, Catanzaro, Italy; Private practice, Cassano allo Jonio, Italy

Thomas Starch-Jensen, DDS, PhD

Professor, Department of Oral and Maxillofacial Surgery, Aalborg University Hospital, Aalborg, Denmark

Andreas Stavropoulos, DDS, MS, PhD

Professor, Department of Periodontology, University of Malmo, Malmo, Sweden

Silvio Taschieri, MD, DDS

Associate Professor, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy

Daniel Thoma, DDS, MSc

Professor, Clinic of Reconstructive Dentistry, Center of Dental Medicine, University of Zurich, Zurich, Switzerland

Leonardo Trombelli, DDS, PhD

Full Professor, Research Centre for the Study of Periodontal and Peri-implant Diseases, University of Ferrara, Ferrara, Italy

Stephen Wallace, DDS

Associate Clinical Professor, Department of Periodontics, Columbia University College of Dental Medicine, New York, NY, USA

Matteo Chiapasco, MD

Associate Professor, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy

Ole T Jensen, DDS, MS

Adjunct Professor, Department of Oral Maxillofacial Surgery, University of Utah, Salt Lake City, UT, USA

Jaime Lozada, DDS

Full Professor, Advanced Education Program in Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, CA, USA

Michael A Pikos, DDS

Adjunct Assistant Professor, Department of Periodontology, School of Dentistry, University of Alabama at Birmingham, Birmingham, AL, USA

Roberto Pistilli, MD

Clinical Assistant Professor, Oral and Maxillofacial Unit, San Camillo Hospital, Rome, Italy

Istvan A Urban, DMD, MD, PhD

Adjunct Clinical Associate Professor, Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, MI, USA; Honorary Professor, University of Szeged, Szeged, Hungary; Lecturer, Harvard School of Dental Medicine, Boston, MA, USA

Pascal Valentini, DDS

Associate Professor, Department of Implant Surgery, Institute of Health, Corte-Tattone Hospital, University of Corsica, Corte, France

Francesco Zuffetti, MD, DDS

Clinical Assistant Professor, IRCCS Galeazzi-Sant'Ambrogio Hospital, Dental Clinic, Section of Implant Dentistry and Oral Rehabilitation, Milan, Italy

Giovanni Felisati, MD

Full Professor, Otolaryngology Unit, Santi Paolo e Carlo Hospital, Department of Health Sciences, University of Milan, Milan, Italy

Alberto Saibene, MD, MA

Researcher, Otolaryngology Unit, Santi Paolo e Carlo Hospital, Department of Health Sciences, University of Milan, Milan, Italy

John R Craig, MD

Head, Department of Otolaryngology – Head and Neck Surgery, Henry Ford Health, Detroit, MI, USA

Hom-Lay Wang, DDS, MSD, PhD

Full Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA

Correspondence to:

Dr Tiziano Testori, c/o Lake Como Institute, Via Rubini 22, 22100 Como, Italy. Email: info@tiziano-testori.it