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# Indications for implant-supported rehabilitation of the posterior atrophic maxilla: A multidisciplinary consensus among experts in the field utilising the modified Delphi method

**KEYWORDS**

*diagnostic procedure, implant dentistry, lateral window technique, pterygoid implants, sinus floor elevation, transcrestal sinus floor elevation, zygomatic implants*

**ABSTRACT**

**Purpose:** To establish consensus-driven guidelines that could support the clinical decision-making process for implant-supported rehabilitation of the posterior atrophic maxilla and ultimately improve long-term treatment outcomes and patient satisfaction.

**Materials and methods:** A total of 33 participants were enrolled (18 active members of the Italian Academy of Osseointegration and 15 international experts). Based on the available evidence, the development group discussed and proposed an initial list of 20 statements, which were later evaluated by all participants. After the forms were completed, the responses were sent for blinded analysis. In most cases, when a consensus was not reached, the statements were rephrased and sent to the participants for another round of evaluation. Three rounds were planned.

**Results:** After the first round of voting, participants came close to reaching a consensus on six statements, but no consensus was achieved for the other fourteen. Following this, nineteen statements were rephrased and sent to participants again for the second round of voting, after which a consensus was reached for six statements and almost reached for three statements, but no consensus was achieved for the other ten. All 13 statements upon which no consensus was reached were rephrased and included in the third round. After this round, a consensus was achieved for an additional nine statements and almost achieved for three statements, but no consensus was reached for the remaining statement.

**Conclusion:** This Delphi consensus highlights the importance of accurate preoperative planning, taking into consideration the maxillomandibular relationship to meet the functional and aesthetic requirements of the final restoration. Emphasis is placed on the role played by the sinus bony walls and floor in providing essential elements for bone formation, and on evaluation of buccopalatal sinus width for choosing between lateral and transcrestal sinus floor elevation. Tilted and trans-sinus implants are considered viable options, whereas caution is advised when placing pterygoid implants. Zygomatic implants are seen as a potential option in specific cases, such as

for completely edentulous elderly or oncological patients, for whom conventional alternatives are unsuitable.

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

## Introduction

Implant-supported rehabilitation of the posterior atrophic maxilla presents unique challenges due to the complex anatomy of the area and the variability of pathophysiological conditions associated with post-extraction alveolar bone resorption and sinus pneumatisation.[1-4] Several surgical options are available, including placement of short and tilted implants, maxillary sinus floor elevation, vertical and horizontal augmentation of the alveolar ridge, and insertion of implants with extramaxillary anchorage.[5-13] During the preoperative planning stage, it is important to evaluate a broad spectrum of therapeutic options thoroughly and assess the advantages and disadvantages of each one. This evaluation should consider not only the biological and economic implications but also the amount of time required for treatment. Various general and local parameters should be assessed, such as systemic conditions, medication intake, smoking habit, periodontal conditions, presence of parafunctional habits, maxillomandibular relationships, quality and quantity of residual bone, maxillary sinus anatomy, homeostasis, pneumatisation, and the number and position of implants based on the prosthetic plan. Patient compliance is also extremely important, as proper home oral care and regular maintenance visits are essential for long-term success of the implant-supported rehabilitation.[14] To establish clear treatment indications, a comprehensive understanding of the available evidence is required. In cases where evidence is limited, a multidisciplinary consensus among experts in the field can provide valuable guidance.[15-17]

The aim of the present clinical consensus statement, organised by the Italian Academy of Osseointegration (IAO), was to assess the level of agreement among experts regarding the indications for implant-supported rehabilitation of the posterior atrophic maxilla using a rigorous and systematic approach. The modified Delphi method[18] was employed, which involves a systematic and iterative process composed of multiple rounds of surveys and feedback from a panel of experts. The panel consisted of experienced oral surgeons, implantologists, periodontists and maxillofacial surgeons who were carefully selected based on their clinical expertise and extensive research contributions in this field.

By leveraging the collective expertise of a diverse panel of experts and utilising the modified Delphi method, the aim was to establish consensus-driven guidelines that could support the clinical decision-making process and ultimately improve long-term treatment outcomes and patient satisfaction.

## Materials and methods

Rosenfeld et al[18] described the protocol that was used for the present modified Delphi consensus. Once the consensus topic was defined, 33 participants were recruited. Of these, 18 were recruited from the active members of the IAO, whereas 15 were international experts (Table 1a). A smaller group (CS, TT, TC and AR), referred to as the development group, was responsible for systematically searching the literature for relevant evidence on the topic. In addition, four facilitators were chosen to coordinate the entire process: two Italians, TC and AR, and two international participants, MS and SY (Table 1b).

**Table 1a** List of IAO and international experts

| Group | Name and qualification suffix(es) | Affiliation(s) |
|---|---|---|
| IAO experts | Tiziano Testori, MD, DDS, MSc, FICD | Head, Section of Implant Dentistry and Oral Rehabilitation, Dental Clinic, IRCCS Orthopaedic Institute Galeazzi Sant'Ambrogio Hospital, Milan, Italy; Adjunct Professor, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy; Adjunct Clinical Associate Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA; Visiting Assistant Professor, Department of Oral Medicine, Infection and Immunity, Harvard School of Dental Medicine, Boston, MA, USA |
| | Eriberto Bressan, DDS, MSc, PhD | Associate Professor, Department of Neurosciences, Section of Dentistry, University of Padua, Padua, Italy; Visiting Professor, Department of Periodontics, International University of Catalonia (UIC Barcelona), Barcelona, Spain |
| | Matteo Chiapasco, MD | Associate Professor, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy |
| | Luca Cordaro, MD, DDS | Head, Department of Periodontology and Prosthodontics, Eastman Dental Hospital, University Policlinic Umberto I, Rome, Italy |
| | Luca De Stavola, DMD, MSc | Visiting Professor, Department of Neurosciences, School of Dentistry, University of Padua, Padua, Italy; Private practice, Padua, Italy |
| | Danilo Alessio Di Stefano, DDS | Adjunct Professor, Dental School, Vita-Salute University IRCCS San Raffaele, Milan, Italy; Private practice, Milan, Italy |
| | Pietro Felice, DDS, MD, PhD | Associate Professor, Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy |
| | Filippo Fontana, DDS, MSc | Private practice, Milan, Italy |
| | Maria Gabriella Grusovin, DDS | Private practice, Gorizia, Italy |
| | Teresa Lombardi, DDS | Adjunct Professor, Department of Health Sciences, Magna Græcia University, Catanzaro, Italy; Private practice, Cassano allo Ionio, Italy |
| | Roberto Pistilli, MD | Clinical Assistant Professor, Oral and Maxillofacial Unit, San Camillo Hospital, Rome, Italy |
| | Marco Ronda, MD, DDS | Private practice, Genova, Italy |
| | Massimo Simion, MD, DDS | Associate Professor, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy |
| | Silvio Taschieri, MD, DDS | Associate Professor, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy |
| | Raffaele Vinci, MD, DMD, MFS | Associate Professor, Department of Dentistry, Vita-Salute San Raffaele University, Milan, Italy |
| | Giovanni Zucchelli, DDS | Full Professor, Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy |
| | Francesco Zuffetti, MD, DDS | Clinical Assistant Professor, IRCCS Orthopaedic Institute Galeazzi, Dental Clinic, Section of Implant Dentistry and Oral Rehabilitation, Milan, Italy |
| | Claudio Stacchi, DDS, MSc | Adjunct Professor, Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy; Private practice, Gorizia, Italy |
| International experts | Zvi Artzi, DMD | Full Professor, Department of Periodontology and Oral Implantology, School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel |
| | Gustavo Avila-Ortiz, DDS, MS, PhD | Full Professor, Department of Periodontics, University of Iowa College of Dentistry, Iowa City, IA, USA |
| | Shayan Barootchi, DMD, MS | Adjunct Clinical Assistant Professor. Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA |
| | Ann Decker, DDS | Assistant Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA |
| | Ole T Jensen, DDS, MS | Adjunct Professor, Department of Oral Maxillofacial Surgery, University of Utah, Salt Lake City, UT, USA |
| | Bach T Le, DDS, MD, FICD, FACD | Clinical Associate Professor, Department of Oral and Maxillofacial Surgery, The Herman Ostrow School of Dentistry of USC Medical Center, Los Angeles, CA, USA |
| | Craig M Misch, DDS, MDS | Adjunct Clinical Associate Professor, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA |
| | Michael A Pikos, DDS | Adjunct Assistant Professor, Department of Periodontology, School of Dentistry, University of Alabama at Birmingham, Birmingham, AL, USA |

**Table 1a** *(cont.)* List of IAO and international experts

| Group | Name and qualification suffix(es) | Affiliation(s) |
|---|---|---|
| International experts | Devorah Schwarz-Arad, DMD, PhD | Private practice, Tel Aviv, Israel |
| | Michael Toffler, DDS | Private practice, New York, NY, USA |
| | Tolga F Tozum, DDS, PhD | Associate Professor, Department of Periodontics, College of Dentistry, University of Illinois Chicago, Chicago, IL, USA |
| | Pascal Valentini, DDS | Associate Professor, Department of Implant Surgery, Institute of Health, Corte-Tattone Hospital, University of Corsica, Corte, France |
| | Stephen S Wallace, DDS | Associate Clinical Professor, Department of Periodontics, Columbia University College of Dental Medicine, New York, NY, 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 |
| | Shih Cheng Wen, DDS, MS | Assistant Professor, School of Dentistry, College of Oral Medicine, Taipei Medical University, Taipei, Taiwan; Private practice, Taipei, Taiwan |

**Table 1b** List of IAO and international facilitators

| Name and qualification suffix(es) | Affiliation(s) |
|---|---|
| Tommaso Clauser, DDS | 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 |
| 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 |
| Shi Yin, DDS, MS | Assistant Professor, Department of Periodontics, Loma Linda University, Loma Linda, CA, USA |

## Literature review

A systematic search of the literature was performed using MEDLINE (via PubMed). The search strategy was as follows:

- Questions 1 to 4: ((atrophic maxilla) OR (posterior maxilla)) AND ((implant) OR (implants) OR (implantology)) AND ((((pre-operative) OR (presurgical) OR (preoperative) OR (presurgical)) AND ((planning) OR (assessment))) OR ((diagnostic wax-up) OR (diagnostic wax up))), no restrictions applied;
- Questions 5 and 6: ((short implant) OR (short implants)) AND ((maxilla) OR (maxillary)), meta-analysis filter applied;
- Questions 7 to 14: ((transcrestal) OR (transalveolar) OR (osteotome) OR (crestal)) AND ((sinus floor elevation) OR (sinus augmentation) OR (sinus lift)), meta-analysis filter applied; ((transcrestal) OR (transalveolar) OR (osteotome) OR (crestal)) AND ((sinus floor elevation) OR (sinus augmentation) OR (sinus lift)) AND ((residual bone height) OR (residual crestal bone) OR (residual crestal bone)), no restrictions applied; ((lateral) OR (window) OR (direct)) AND ((sinus floor elevation) OR (sinus augmentation) OR (sinus lift)), meta-analysis and systematic review filters applied;
- Questions 15 to 17: ((atrophic maxilla) OR (posterior maxilla)) AND ((implant) OR (implants) OR (implantology)) AND ((tilted) OR (angulated)), no restrictions applied;
- Questions 18 to 20: ((atrophic maxilla) OR (posterior maxilla)) AND ((implant) OR (implants) OR (implantology)) AND ((zygomatic) OR (zygoma)), meta-analysis and systematic review filters applied.

The titles and abstracts of the articles obtained were screened and selected by the development group, and the full texts were sent to all the participants.

Based on the available evidence, the development group discussed and proposed an initial list of 20 statements, which were later evaluated by all participants. An assistant, who was not involved in the consensus process, assigned a four-character code to each participant. The participants were blinded, as they only knew their own code. TC was

responsible for the analysis and was only aware of whether a code was assigned to an international participant or an IAO member.

Three rounds of voting were planned. All participants received the list of statements in the form of a survey, which was created and shared using Google Forms (Google, Mountain View, CA, USA). They were asked to rate their agreement with each statement on a Likert scale ranging from 1 ("completely disagree") to 9 ("completely agree"), and to leave comments for any statements they disagreed with. After the forms were completed, the responses were sent for analysis.

All the responses were collected in a Google Sheet and analysed using RStudio (RStudio Team, Boston, MA, USA). Each statement in the list was assigned to one of the following groups based on the overall level of agreement:

- Consensus: mean score ≥ 7 with no more than one outlier (an outlier was defined as a value outside the mean score by ± 2 Likert points);
- Near-consensus: mean score ≥ 6.5 with no more than two outliers;
- No consensus: a statement that did not meet the criteria for "consensus" or "near-consensus".

Statements upon which a consensus was reached were excluded from the next round, if planned, whereas near-consensus statements were re-evaluated. The anonymous comments, which were mandatory for statements a participant disagreed with and optional for scores above 6, were used by the development group to rephrase the statements that advanced to the next round.

All participants received the analysis of the data from the previous round, along with a new survey for the next voting round, if planned. Due to the number of participants, it was decided that only the development group would participate in the discussion aimed at rephrasing the statements.

## Results

After the first round of voting, participants came close to reaching a consensus on six statements, but no consensus was achieved for the other fourteen. Following this, nineteen statements were rephrased and sent to participants again for the second round of voting, after which a consensus was reached for six statements and almost reached for three statements, but no consensus was achieved for the other ten. All 13 statements upon which no consensus was reached were rephrased and included in the third round. After this round, a consensus was achieved for an additional nine statements and almost achieved for three statements, but no consensus was reached for the remaining statement.

The final mean agreement and number of outliers for all statements are presented in Table 2. By the end of the process, a consensus had been reached for the following 15 statements:

- Statement #1: To reconstruct an atrophic posterior maxilla with an implant-supported prosthesis in partially edentulous patients, a diagnostic wax-up (either analogue or virtual) could help to evaluate horizontal and/or vertical deficiency and determine the most appropriate treatment plan.
- Statement #2: A thorough preoperative assessment can foster the manufacturing of a fixed prosthesis with a morphology that limits retention of food and debris and favours maintenance with routine hygienic home care procedures to reduce the risk of peri-implant disease.
- Statement #3: In partially edentulous patients, when maxillary sinus elevation alone is not sufficient to fulfil the prosthetic requirements (function, aesthetics and maintainability), alveolar ridge augmentation (horizontal and/or vertical) can be considered.
- Statement #4: In partially edentulous patients, residual bone height is only one of the variables to be assessed during pre-surgical planning. Other relevant variables are horizontal and/or vertical bone deficiency, sinus health, anatomy and soft tissue conditions.
- Statement #7: Vital bone formation after maxillary sinus augmentation is inversely proportional to the sinus bucco-palatal distance at the augmentation site.
- Statement #8: New bone formation after maxillary sinus floor elevation originates primarily from the bony walls and sinus floor, whereas the

**Table 2** Final median and mean agreement and number of outliers for all statements. An outlier was defined as a value outside the mean score by ± 2 Likert points. With a low mean score (i.e., < 7), a strong agreement (e.g., 9) was considered an outlier. The number of outliers below the mean are given in parentheses

| # | Statement | Last round | Median agreement | Mean agreement | Italian outliers | International outliers | Total outliers | Level of agreement in the last round |
|---|---|---|---|---|---|---|---|---|
| 1 | To reconstruct an atrophic posterior maxilla with an implant-supported prosthesis in partially edentulous patients, a diagnostic wax-up (either analogue or virtual) could help evaluate horizontal and/or vertical deficiency and determine the most appropriate treatment plan | 2 | 9 | 8.67 | 1 | 0 | 1 | Consensus |
| 2 | A thorough preoperative assessment can foster the manufacturing of a fixed prosthesis with a morphology that limits retention of food and debris and favours maintenance with routine hygienic home care procedures to reduce the risk of peri-implant disease | 3 | 9 | 8.50 | 0 | 0 | 0 | Consensus |
| 3 | In partially edentulous patients, when maxillary sinus elevation alone is not sufficient to fulfil the prosthetic requirements (function, aesthetics and maintainability), alveolar ridge augmentation (horizontal and/or vertical) can be considered | 3 | 9 | 8.83 | 0 | 0 | 0 | Consensus |
| 4 | In partially edentulous patients, residual bone height is only one of the variables to be assessed during pre-surgical planning. Other relevant variables are horizontal and/or vertical bone deficiency, sinus health, anatomy and soft tissue conditions | 2 | 9 | 8.79 | 0 | 0 | 0 | Consensus |
| 5 | In edentulous posterior maxillae presenting vertical ridge deficiency, short implants (endosseous portion ≤ 8 mm) can be a safe alternative to bone augmentation | 3 | 9 | 7.77 | 3 | 0 | 3 | No consensus |
| 6 | Implant primary stability may be improved by the engagement of the implant apex in the cortical layer of the sinus floor | 3 | 9 | 8.22 | 2 | 0 | 2 | Near-consensus |
| 7 | Vital bone formation after maxillary sinus augmentation is inversely proportional to the sinus bucco-palatal distance at the augmentation site | 3 | 9 | 8.61 | 0 | 0 | 0 | Consensus |
| 8 | New bone formation after maxillary sinus floor elevation originates primarily from the bony walls and sinus floor, whereas the regenerative contribution of the sinus membrane is less pronounced | 3 | 9 | 8.44 | 0 | 0 | 0 | Consensus |
| 9 | In the transcrestal approach, adequate membrane elevation from the sinus bony walls is predictable only in narrow sinus cavities | 1 | 7 | 5.77 | 9 (2) | 11 (8) | 20 (10) | Near-consensus |
| 10 | Sinus bucco-palatal width should be evaluated when planning transcrestal sinus floor elevation, especially for replacement of multiple teeth | 2 | 9 | 8.50 | 1 | 0 | 1 | Consensus |
| 11 | The height, width and quality of the residual bone crest, along with the operator learning curve, should be considered when planning sinus floor augmentation with simultaneous implant insertion | 2 | 9 | 8.79 | 0 | 0 | 0 | Consensus |
| 12 | When planning for a crestal or lateral sinus augmentation approach, the number of planned implants is among the factors to be evaluated | 3 | 8.5 | 8.11 | 2 | 0 | 2 | Near-consensus |
| 13 | In patients with only one or two teeth missing between natural teeth with adequate bucco-palatal ridge width (≥ 6 mm) and residual bone height ≥ 4 mm, transcrestal sinus floor elevation could be considered | 3 | 9 | 8.61 | 0 | 0 | 0 | Consensus |

| # | Statement | Last round | Median agreement | Mean agreement | Italian outliers | International outliers | Total outliers | Level of agreement in the last round |
|---|---|---|---|---|---|---|---|---|
| 14 | In patients with missing premolars and molars who need maxillary sinus elevation with multiple implant placement, the lateral window technique may be a more convenient surgical approach than a crestal approach | 3 | 9 | 8.16 | 2 | 0 | 2 | Near-consensus |
| 15 | Implants tilted mesially or distally to avoid maxillary sinus elevation can be a viable option in selected patients or when maxillary sinus elevation is contraindicated | 3 | 9 | 8.66 | 1 | 0 | 1 | Consensus |
| 16 | Tilted implants placed inside the sinus cavity after sinus membrane distalisation (trans-sinus implants) may be a viable option in selected cases | 3 | 8.5 | 7.72 | 1 | 0 | 1 | Consensus |
| 17 | Pterygoid implants may be indicated in selected cases (when patients cannot undergo complex surgery for various psychological and/or clinical reasons), even though their placement is more surgically challenging and their hygienic maintenance more difficult | 2 | 9 | 8.11 | 1 | 0 | 1 | Consensus |
| 18 | Zygomatic implants should be considered in certain completely edentulous patients only when standard implant placement is not possible and regenerative procedures cannot be performed | 3 | 9 | 8.50 | 0 | 0 | 0 | Consensus |
| 19 | Zygomatic implants can be a viable option in certain completely edentulous elderly patients and/or in oncological patients when other therapeutic options are not considered adequate | 3 | 9 | 8.27 | 1 | 0 | 1 | Consensus |
| 20 | Zygomatic implants are usually not indicated in partially edentulous patients but may be used in selected cases, such as when there is a severe lack of bone following oncological resection or another form of severe atrophy with preserved natural dentition in other areas of the mouth | 2 | 9 | 8.00 | 1 | 0 | 1 | Consensus |

regenerative contribution of the sinus membrane is less pronounced.

- Statement #10: Sinus bucco-palatal width should be evaluated when planning transcrestal sinus floor elevation, especially for replacement of multiple teeth.
- Statement #11: The height, width and quality of the residual bone crest, along with the operator learning curve, should be considered when planning sinus floor augmentation with simultaneous implant insertion.
- Statement #13: In patients with only one or two teeth missing between natural teeth with adequate bucco-palatal ridge width (≥ 6 mm) and residual bone height ≥ 4 mm, transcrestal sinus floor elevation could be considered.
- Statement #15: Implants tilted mesially or distally to avoid maxillary sinus elevation can be a viable option in selected patients or when maxillary sinus elevation is contraindicated.
- Statement #16: Tilted implants placed inside the sinus cavity after sinus membrane distalisation (trans-sinus implants) may be a viable option in selected cases.
- Statement #17: Pterygoid implants may be indicated in selected cases (when patients cannot undergo complex surgery for various psychological and/or clinical reasons), even though their placement is more surgically challenging and their hygienic maintenance more difficult.
- Statement #18: Zygomatic implants should be considered in certain completely edentulous

patients only when standard implant placement is not possible and regenerative procedures cannot be performed.
- Statement #19: Zygomatic implants can be a viable option in certain completely edentulous elderly patients and/or in oncological patients when other therapeutic options are not considered adequate.
- Statement #20: Zygomatic implants are usually not indicated in partially edentulous patients but may be used in selected cases, such as when there is a severe lack of bone following oncological resection or another form of severe atrophy with preserved natural dentition in other areas of the mouth.

Near-consensus was reached on the following statements:
- Statement #6: Implant primary stability may be improved by the engagement of the implant apex in the cortical layer of the sinus floor.
- Statement #12: When planning for a crestal or lateral sinus augmentation approach, the number of planned implants is among the factors to be evaluated.
- Statement #14: In patients with missing premolars and molars who need maxillary sinus elevation with multiple implant placement, the lateral window technique may be a more convenient surgical approach than a crestal approach.

No consensus was achieved on the following statements:
- Statement #5: In edentulous posterior maxillae presenting vertical ridge deficiency, short implants (endosseous portion ≤ 8 mm) can be a safe alternative to bone augmentation.
- Statement #9: In the transcrestal approach, adequate membrane elevation from the sinus bony walls is predictable only in narrow sinus cavities.

## Discussion

The first four statements highlight the consensus reached among the experts on the importance of accurate preoperative planning to select the most appropriate treatment options for each specific case. A diagnostic wax-up, whether performed using analogue or virtual methods, can be extremely beneficial in evaluating horizontal and vertical deficiencies of the edentulous ridge and considering them in the decision-making process. Clinicians can obtain a visual representation of maxillomandibular relationships and simulate the final prosthetic outcome. This approach allows for a more accurate assessment of the space available for implant-supported rehabilitation, helping to select the most suitable treatment options tailored to the specific anatomical and functional features of each individual case. Thorough preoperative planning plays a crucial role in achieving a fixed prosthesis that meets functional and aesthetic requirements, while also promoting easy maintenance through routine home care procedures by minimising retention of food and debris. However, in cases of severe atrophy of the posterior maxilla where meeting these prosthetic requirements becomes challenging, alveolar ridge augmentation procedures (both horizontal and/or vertical) should be considered to restore favourable maxillomandibular relationships. Simply evaluating the available bone volume for implant placement is insufficient. This information needs to be integrated into a comprehensive analysis of the patient, taking into account factors such as prosthetic, occlusal and aesthetic considerations. This holistic approach ensures optimal treatment outcomes for the patient.

Statements #7, #8, #10 and #13 address the biological mechanisms that regulate new bone formation after maxillary sinus floor elevation and their influence on clinical decisions. A consensus was reached on the notion that vital bone formation after lateral or transcrestal maxillary sinus augmentation is inversely proportional to the sinus bucco-palatal distance at the augmentation site (statement #7).[10,19-21] A consensus was also achieved regarding the pivotal role played by the sinus bony walls and floor (statement #8), as they serve as the primary source of osteoprogenitor cells and blood supply required for new bone formation.[22] The contribution of the sinus membrane to bone regeneration, on the other hand, is comparatively less significant.[23] Thus, to maximise the regenerative potential of the sinus cavity, it

is necessary to elevate the membrane from both the lateral and medial sinus walls, allowing for close contact between the host bone and the grafting material. In the lateral approach, the surgeon can elevate the membrane directly, ensuring adequate exposure of the bone walls; however, in the transcrestal approach for large sinus cavities, it is not always possible to achieve predictable membrane elevation due to its indirect nature and the lack of control.[10] The participants in this Delphi consensus agreed that the buccopalatal width of the sinus should be evaluated when planning transcrestal sinus floor elevation, especially for multiple tooth replacement (statement #10). An exception can be made for patients with only one or two missing teeth between natural teeth, where transcrestal sinus floor elevation could be considered (statement #13). In this case, even in the presence of large sinus cavities, the alveolar bone supporting the adjacent teeth (mesial and distal) may provide an additional osteogenic surface, compensating for possible inadequate membrane elevation from the lateral and medial sinus walls.

Finally, a consensus was achieved regarding the necessity of carefully considering the height, width and quality of the residual bone crest, along with the operator's learning curve, when planning sinus floor augmentation with simultaneous implant insertion (statement #11). It is not possible to establish a minimal crestal height for simultaneous implant placement, whether using the lateral or transcrestal approach. Many concurrent factors should be evaluated to minimise the risk of implant displacement into the sinus cavity, a complication that is increasingly reported in the literature.[24]

Part of the present Delphi consensus focused on implant-supported rehabilitation of the atrophic posterior maxilla using the residual native bone, without the association of regenerative procedures. It is interesting to note that, despite the fact that numerous articles and meta-analyses report encouraging clinical outcomes for short implants in the posterior maxilla[2,5,6,25,26], no consensus was reached for statement #5 (short implants with an endosseous portion ≤ 8 mm can be a safe alternative to bone augmentation). The main concern of the three outliers was that current data on short implants in the posterior maxilla are still limited, and further long-term studies are needed before their routine use in clinical practice can be recommended. Conversely, a consensus was reached on the use of tilted implants. Participants agreed that implants tilted mesially or distally to avoid maxillary sinus elevation or tilted implants placed inside the sinus cavity after sinus membrane distalisation (trans-sinus implants) may both be viable options in selected cases (statements #15 and #16), in accordance with numerous studies that have reported positive clinical results with this approach.[7,8,27-30] A consensus was also achieved on the use of pterygoid implants, which may be indicated in selected cases where patients cannot undergo complex surgery for various psychological and/or clinical reasons (statement #17); however, the statement emphasises that pterygoid implant placement is surgically challenging and requires careful consideration of anatomical landmarks to avoid intraoperative complications[31,32], and that performing hygiene maintenance is more difficult than with standard implants.

Lastly, a consensus was achieved among the participants regarding implants with extra-maxillary anchorage (statements #18, #19 and #20). The experts invited to participate in this Delphi consensus process recommended that zygomatic implants be considered in certain completely edentulous patients only when standard implant placement is not possible and regenerative procedures cannot be performed. It is also important to emphasise that zygomatic implants are usually not indicated in partially edentulous patients but may be used in selected cases, such as in the event of severe bone loss following oncological resection or other forms of severe atrophy, with preserved natural dentition in other areas of the mouth. Finally, it was suggested that zygomatic implants could be a viable option in certain completely edentulous elderly patients and/or in oncological patients when other therapeutic options are not considered adequate. In summary, taking into account the wide range of possible intraoperative, prosthetic and late biological and mechanical complications, zygomatic implants should be viewed as a last resort treatment option for patients with extremely severe maxillary bone atrophy.[13,33,34] It is crucial for patients who are considering zygomatic implants to consult with a skilled

and experienced dental professional who can evaluate their case thoroughly and determine the most appropriate treatment plan.

## Conclusion

The experts reached a consensus on the following points:

- Accurate preoperative planning is important to select the most appropriate treatment options for each specific case. A diagnostic wax-up, whether performed using analogue or virtual methods, can be extremely beneficial in evaluating the horizontal and vertical deficiencies of the edentulous ridge and considering them in the decision-making process.
- Maxillary sinus anatomy has an impact on the regenerative potential of the surgical site, as new bone formation after maxillary sinus floor elevation is influenced by the bucco-palatal width of the sinus cavity.
- The sinus bony walls and floor, which provide the primary source of osteoprogenitor cells and blood supply necessary for new bone formation, play a pivotal role. The regenerative contribution of the sinus membrane is comparatively less pronounced.
- The evaluation of bucco-palatal width of the sinus is crucial when planning transcrestal sinus floor elevation, particularly for multiple tooth replacement; however, an exception can be made for patients with only one or two missing teeth between natural teeth, where transcrestal sinus floor elevation could be considered.
- Implants tilted mesially or distally to avoid maxillary sinus elevation or tilted implants placed inside the sinus cavity after sinus membrane distalisation (trans-sinus implants) can be considered a viable treatment option.
- The surgical challenge posed by pterygoid implant placement requires careful consideration of anatomical landmarks to avoid intraoperative complications. Additionally, it is important to note that hygienic maintenance of pterygoid implants is more difficult compared to that of standard implants.
- Zygomatic implants can potentially be used in certain completely edentulous elderly patients and/or in oncological patients when other therapeutic options are deemed inadequate.

No consensus was reached among the experts on short implants, despite the fact that numerous articles and meta-analyses have reported encouraging clinical outcomes for them in the posterior maxilla.

## References

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