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A proposed classification for zygomatic implant patients based on the zygoma anatomy guided approach (ZAGA): a cross-sectional survey

Key words  atrophic maxilla, dental implants, extra-sinus pathway, zygomatic implants

This classification, on the ‘Zygoma Anatomy Guided Approach’ (ZAGA), was first introduced at the 3-I Spanish Annual Symposium held in Madrid January 2010.

Purpose: The aim of the present cross-sectional study was to propose a classification system based on a cross-sectional survey of zygomatic implant cases.

Materials and methods: Cone beam computerised tomography (CBCT) postoperative images and clinical intra-surgery photographs of 200 sites corresponding to 100 patients, treated with a total of 198 zygomatic implants in the maxilla according to an anatomy-driven prosthetic approach, were reviewed with regard to anatomy and pathway of the zygomatic implant body. The patients were consecutively selected independently of the type of surgery performed, with the unique requirement of a post-surgical CBCT performed at the moment of selection. Of special interest was the morphology of the lateral sinus wall, residual alveolar crest and the zygomatic buttress. An attempt was made to divide the patients into groups, describing typical anatomies and implant pathways.

Results: Five basic skeletal forms of the zygomatic buttress–alveolar crest complex and subsequent implant pathways could be identified in a sample of 100 patients. Out of them, 62% were female and 38% male, with ages varying between 36 and 83 years (mean age 59.6, SD: 9.67). The five groups were classified as ZAGA 0 to 4 representing 15%, 49%, 20.5%, 9% and 6.5% of the studied sites, respectively. Intra-individual anatomical differences affecting the zygomatic buttress–alveolar crest complex was also found in 58% of the patients.

Conclusions: Five typical anatomical and implant pathway situations could be identified. A classification system comprising five groups named ZAGA 0 to 4 is proposed. Anatomical intra-individual differences were also found in the 58% of the studied population. It is believed that the proposed classification system is useful for categorising zygomatic implant cases for therapy planning and for scientific follow-up purposes.

Conflict-of-interest statement: There is no financial conflict of interest.
Introduction

Zygomatic implants *ad modum* Brånemark are used for prosthetic rehabilitation of the severely resorbed maxilla. The original technique prescribed an intra-sinus pathway of the implant and preparation of a window in the anterior wall of the maxillary sinus to allow visualisation of the zygomatic bone during insertion of the implant. Different morphologies of the edentulous maxilla can be identified and in many cases the original procedure results in a marked palatal position of the implant head. This in turn results in bulky prosthetic constructions and impaired hygiene.

In order to use an anatomically and prosthetically driven approach, the original technique has been modified by also allowing an extra-sinus path for zygomatic implants. With this novel approach, no initial window or slot is opened at the lateral wall of the maxillary sinus. The preparation of the implant site is guided by the anatomy of the area instead. Firstly, the coronal entrance point at the level of the alveolar process, for an optimal prosthetic outcome, is determined according to prosthetics, biomechanics and anatomical parameters. Secondly, the apical zygomatic entrance point is identified based on the desired number and length of the implant(s) and the anatomy. Thirdly, the implant trajectory is planned by joining the two points, which will determine the preparation and pathway of the implant body. Thus, depending on the relation between the zygomatic buttress and the intraoral starting point of the zygomatic implant, the path of the implant body will vary from a total intra-sinus to a total extra-sinus one.

Despite the fact that zygomatic implants have been used for more than two decades, there are no randomised controlled trials evaluating their clinical effectiveness in relation to alternative means for rehabilitating patients with atrophic edentulous maxillae. At the same time, there is no classification system describing the various anatomy-guided zygomatic implant pathways at present. The aim of the present cross-sectional survey was to propose a classification system based on a retrospective review of zygomatic implant cases. This report is presented following the STROBE guidelines for observational studies (http://www.strobe-statement.org/).

Materials and methods

After a prospective report of 131 zygomatic implants placed between 1998 and February 2004, the original technique was progressively modified using a zygoma anatomy guided approach (ZAGA). Cone beam computerised tomography (CBCT) postoperative images and clinical intra-surgery photographs of 200 sites corresponding to 100 of the 177 total patients treated between April 2005 and December 2010 with zygomatic implants according to the referred anatomy-driven prosthetic approach, were reviewed by an independent investigator with regard to anatomy and pathway of the zygomatic implant body. Of special interest was the morphology of the lateral sinus wall, residual alveolar crest and the zygomatic buttress. An attempt was made to classify the patients into groups, describing typical anatomies and implant pathways. Since the results were intended to be given in percentages, a sample of 100 consecutive zygoma patients was chosen from the total pool of 177 patients treated with zygoma implants between April 2005 and December 2010. April 2005 was chosen as landmark date to consider ZAGA fully implemented in the author’s centre. The patients were consecutively selected independently of the type of surgery performed, with the unique requirement of a post-surgical CBCT performed at the moment of the selection. A total of 198 zygomatic implants were installed: 73 patients had 2 zygomatic implants each, 2 patients had 3 zygomatic implants each, 7 were treated with 4 zygomatic implants and 18 patients received 1 zygomatic implant. Additional regular implants were used when needed.

All of the implants were placed by the same surgeon in a single centre: Clinica Aparicio, Barcelona, Spain. The main inclusion criteria for treating patients with zygomatic implants was the presence of a residual alveolar crest less than 4 mm in width and height, immediately distal to the canine pillar. When treating partial edentulism, the possibility of establishing a tripodisation by placing a minimum of three implants per quadrant, one zygomatic plus two regular, was required. CBCT post-surgical images were required to be included in this study. The exclusion criteria were acute sinus infection and lack of permeability of the osteomeatal complex.
Results

Five basic skeletal forms of the zygomatic buttress–alveolar crest complex and subsequent implant pathways could be identified in a sample of 100 patients. A total of 62% were female and 38% male, with ages varying between 36 and 83 years (mean age 59.6, SD 9.67). The five groups were named from ZAGA 0 to 4 representing 15%, 49%, 20.5%, 9% and 6.5% of the studied sites, respectively.

Group 0 (ZAGA 0)
- The anterior maxillary wall is very flat.
- The implant head is located on the alveolar crest.
- The implant body has an intra-sinus path.
- The implant comes into contact with bone at the alveolar crest and zygomatic bone, and sometimes at the lateral sinus wall (Fig 1).

This group represented 15% of the reviewed implants.

Group 1 (ZAGA 1)
- The anterior maxillary wall is slightly concave.
- The implant head is located on the alveolar crest.
- The drill has performed the osteotomy slightly through the wall.
- Although the implant can be seen through the wall, most of the implant body has an intra-sinus path.
- The implant comes into contact with bone at the alveolar crest, lateral sinus wall and zygomatic bone (Fig 2).

This group represented 49% of the reviewed implants.

Group 2 (ZAGA 2)
- The anterior maxillary wall is concave.
- The implant head is located on the alveolar crest.
- The drill has performed the osteotomy through the wall.
- The implant can be seen through the wall and most of the body has an extra-sinus path.
- The implant comes into contact with bone at the alveolar crest, lateral sinus wall and zygomatic bone (Fig 3).

This group represented 20.5% of the reviewed implants.
Fig 2  ZAGA 1 case:
a) schematic and
b) clinical example.
ZAGA 1 is characterised by the following:
anterior maxillary wall is slightly concave; implant head is located on the alveolar crest; drill has performed the osteotomy slightly through the wall and most of the implant body has an intra-sinus path.

Fig 3  ZAGA 2 case:
a) schematic and
b) clinical example.
ZAGA 2 is characterised by the following:
anterior maxillary wall is concave; implant head is located on the alveolar crest; drill has performed the osteotomy through the wall and most of the implant body has an extra-sinus path.
Group 3 (ZAGA 3)
- The anterior maxillary wall is very concave.
- The implant head is located on the alveolar crest.
- The drill has performed the osteotomy following a trajectory that goes from the palatal to the upper buccal alveolar bone, then the implant body leaves the concave part of the anterior sinus wall to penetrate into the zygomatic bone.
- Most of the implant body has an anterior extrasinus path.
- The middle part of the implant body is not touching the most concave part of wall.
- The implant comes in contact with bone in the coronal alveolar and apical zygomatic bone (Fig 4).

This group represented 9% of the reviewed implants.

Group 4 (ZAGA 4)
- The maxilla and the alveolar bone show extreme vertical and horizontal atrophy.
- The implant head is located buccally of the alveolar crest. There is no or minimal osteotomy at this level.
- The drill has arrived at the apical zygomatic entrance following a path outside the sinus wall.
- Most of the implant body has an extra-sinus/extra-maxillary path. Just the apical part of the implant is surrounded by bone.
- The implant comes in contact with bone in the zygomatic bone and part of the lateral sinus wall (Fig 5).

This group represented 6.5% of the reviewed implants.

In addition, 58% of the patients showed anatomical differences between left and right zygomatic buttress–alveolar crest complexes. In other words, right and left sites of 58 patients were classified as different ZAGA groups.
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**Discussion**

To the best of the present author’s knowledge, no classification system exists to describe the various anatomy-guided zygomatic implant pathways related to the zygomatic buttress–alveolar crest complex. Based on a cross-sectional study of 200 sites, a classification system comprising five basic anatomical groups named from ZAGA 0 to 4 is proposed. This classification system is based on the author’s clinical experience with the original zygomatic implant technique and subsequent development in order to reduce the bulkiness of the fixed dental prosthesis. The latter study reported on a 3-year period using zygomatic implants placed with this modified technique in 20 patients with extreme buccal concavities in the maxillary sinus areas. In addition, all patients but one received a fixed construction within 24 hours after surgery. After a mean follow-up of 41 months, no implants were removed, and no acute sinus infection or unexpected tissue reactions to the zygomatic implants were observed. Moreover, the extra-sinus technique enabled placement of the implant head at or near the top of the residual crest, which resulted in a more normal extension of the fixed dental prosthesis framework.

The present proposed classification could help the clinician to refine the original technique for the placement of zygomatic implants by understanding the possibility of finding not only inter-individual anatomy differences but also intra-individual ones. Establishment of the intraoral coronal entrance point at the alveolar process is the key factor for a successful outcome of the ZAGA procedure. The implant head should be placed at or near the top of the alveolar crest, with a mesiodistal entrance at the level of the second premolar/first molar regions. By following specific prosthetic, biomechanical and anatomical factors, the intraoral entrance point depends on the vertical and horizontal resorption of the alveolar/basal process and on the anterior maxillary wall curvature. Guided by these factors, the intraoral preparation can start either on the bone crest (buccally of the crest in the shape of a lateral canal) or, in cases of severe resorption, the first perforation can be performed extraorally, directly on the zygomatic buttress.

![Fig 5 ZAGA 4 case: a) schematic and b) clinical example.](image)

ZAGA 4 is characterised by the following: maxilla and the alveolar bone show extreme vertical and horizontal atrophy; implant head is located buccally of the alveolar crest (there is no or minimal osteotomy at this level); drill has arrived at the apical zygomatic entrance following a path outside the sinus wall and most of the implant body has an extra-sinus/extra-maxillary path.
A tendency to place the zygomatic implants more and more externally to the maxillary wall during the last 3 years has been noticed. Clinical follow-up studies have shown good outcomes and no obvious irritation of the overlaying soft tissues, though there is a complete lack of valid comparative trials.

Due to the technical difficulty of matching the CBCT slice with the oblique trajectory of the implant, especially when two implants are placed in one zygomatic bone, when needed, the help of clinical photographs was used to clarify the CBCT images.

**Conclusions**

Five basic skeletal forms of the zygomatic buttress–alveolar crest complex and implant pathways have been identified. A classification system comprising five basic anatomical groups named from ZAGA 0 to 4 is proposed. Anatomical intra-individual differences have also been found in 58% of the studied population. It is believed that the proposed system is useful for classifying zygomatic implant cases for therapy planning and for scientific follow-up purposes.

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**References**