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Assessment Of Bone Swatch Along With ZAGA Grading For Zygomatic Implants In South Indian Population- A CBCT Study

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Objective: The aim of this study was to analyze and compare the bone length from crest of 1st molar to zygoma for placement of zygomatic implants in the South Indian population using cone beam computed tomography (CBCT). The secondary objectives were to evaluate and compare the ZAGA grading between gender and to assess the prevalence and distribution of pneumatization patterns of articular eminence.

Materials and Methods: A total of 200 CBCT scans of partially edentulous patients were evaluated. The distance from the crest of the 1st molar to the zygoma was measured to assess the available bone length and was compared between gender. Th Zygomatic Anatomy-Guided Approach (ZAGA) grading was also compared between gender. The lacunarity and patterns of pneumatization of articular eminence were evaluated.

Results: The mean distances measured were 44.8±1.39 mm in males and 40.37±0.48 mm in females respectively. To compare the available bone length between gender, the mean values of the distances were found by performing an independent t test. Statistically significant relation was found in relation to bone length and gender. No statistically significant relation was found in the distribution and lacunarity of pneumatization of the articular eminence between gender which was established by performing chi square test. Grade 1 pneumatization of the articular eminence was highly prevalent in males, while Grade 2 was highly prevalent in females. There was a high prevalence of ZAGA 1 in females and ZAGA 2 in males. The association between gender and grading of ZAGA were found by performing a chi square test.
Conclusion: The study emphasizes the importance of understanding the maxillary sinus anatomy to determine the appropriate path of insertion for zygomatic implants. It is crucial to assess available bone length prior to implant placement and to have knowledge about the distribution of pneumatization of the articular eminence to prevent complications during and after surgery.

Key words pneumatization of articular eminence; zygomatic implants ; cone beam computed tomography ; Zygoma anatomy guided approach, maxillary sinus

INTRODUCTION:

Dental implants have a rich history and are commonly used to replace missing teeth caused by various factors such as disease, trauma, and aging [1]. Dr. Norman Goldberg made significant advancements in implantology during World War II by using metals for dental repair, which later extended to other parts of the body. Over time, different types of implants, including subperiosteal and titanium implants, were developed. Today, dental implants have become a popular option for restoring missing teeth in oral rehabilitation. The success of an implant depends on its proper integration with the surrounding tissues, known as osseointegration [2]. Placing implants in the posterior maxilla, especially in patients with insufficient bone height, has been a topic of debate. Insufficient bone volume in the upper jaw can occur due to bone loss or the expansion of the maxillary sinus, making implant placement challenging. To address this, various implant design modifications such as shorter or narrower implants have been used, along with supplemental procedures like augmentation of bone, sinus lift procedures, and onlay bone grafting, to increase the amount of supportive bone [3]. However, these procedures can have complications and are specific to each individual, potentially leading to issues like sinusitis. Therefore, alternative treatment approaches have been explored, including the placement of zygomatic implants, particularly in cases of severe upper jaw atrophy [4]. However, the triumph of zygomatic implants is highly dependent on the anatomical characteristics of the region, particularly the presence of pneumatization of the articular eminence.

Branemark first offered zygomatic implants as a treatment option for atrophic maxilla and deformities caused by maxillectomy in 1997 [5]. They provide an innovative implantation method created especially for the posterior maxilla region. These implants speed up the rehabilitation process in addition to providing anchoring in the posterior maxilla. The zygomatic implant is placed inside the zygoma bone after being introduced through the maxillary sinus cavity or along the lateral sinus wall [6]. Patients who use zygoma implants report better function, aesthetics, and social comfort, which contributes to overall happiness with their recovered oral health. It is crucial to remember that this procedure does not come without risks because it works on delicate anatomical components like the orbit, which calls for the right knowledge and training. The increased length of implant body and the delicate

nature of maxillary-zygomatic complex require careful consideration of the insertion path. In the past, the implant was put through an intra-sinus channel, and a window was made in the maxillary sinus's anterior wall to enhance view of the zygomatic bone during placement. The ZAGA strategy, which calls for a less invasive zygomatic osteotomy, has emerged as a more creative and patient-specific method, though [7]. In this technique, a mucoperiosteal flap is elevated to access the surgical area, which includes the superior orbital rim and posterior wall of the maxillary sinus, instead of making an incision or creating an opening in the lateral wall of the maxillary sinus [8]. Previous studies have consistently shown that this approach, when combined with innovative implant designs following the Zygomatic Anatomy-Guided Approach (ZAGA) concept, offers several advantages [7,8]. These include reduced trauma during osteotomy, enhanced stability of the implant, improved bone-to-implant contact, and better sealing of the bone around the implant neck. Furthermore, the utilization of this method helps prevent complications such as penetration into the infratemporal fossa.

Reduced resistance is present in pneumatized regions inside the temporal bone, which fosters the growth of many diseases [9]. Functional effects of temporal bone pneumatization include reducing skull resonance, improving sound reception, and serving as a middle air reservoir [10]. The initial documentation of the pneumatization of the articular eminence resembling mastoid air cells was presented by Tyndall and Matteson [11]. This condition, which is asymptomatic, is limited to the zygomatic process of the temporal bone and the articular eminence. It does not extend beyond the zygomaticotemporal suture [11]. Radiographically, it appears as a radiolucent defect without any cortical destruction or extension. Additionally, pneumatization can aid in the growth of tumors, infections, and fractures. Furthermore, accidental penetration during surgical procedures in these regions may raise the risk of cerebrospinal fluid leakage [12].

Previous studies have evaluated pneumatized articular tubercles using a variety of imaging techniques [8,9,10,12]. Traditional two-dimensional intraoral radiographs include drawbacks such as elongation of images, poor image quality, and increased radiation exposure. CBCT, on the other hand, offers standard resolution pictures of the craniofacial region that are accurate and detailed [13]. It offers the advantage of lower radiation dosage compared to traditional computed tomography while covering the same area [14-15].

CBCT imaging, with its superior resolution and three-dimensional visualization, has emerged as a valuable tool in implant dentistry [15]. The utilization of CBCT data will enable the examination of a large sample size, enhancing the generalizability of the findings [16]. Furthermore, the inclusion of various demographic variables, such as age, sex, and systemic health parameters, will help identify potential associations and provide a comprehensive understanding of the South Indian population's unique characteristics [17].

The South Indian population presents unique anatomical variations, necessitating population-specific studies to optimize treatment outcomes [17-18]. By analyzing the preponderance and attributes of pneumatized articular tubercle, clinicians can better understand the potential challenges associated with zygomatic implant placement in this population. Furthermore, evaluating the suitability of bone swatch for zygomatic implants using the ZAGA grading

system will provide valuable insights into treatment planning and improve the predictability of clinical outcomes.
Therefore, the primary objective of the CBCT study is to assess and compare crucial insights into the availability of bone length for zygomatic implants, and also to compare the ZAGA grading system between gender . The secondary objectives were to evaluate the prevalence of patterns and grading of pneumatized articular eminence between gender in the South Indian population. Hence, the following study thereby aims to improve treatment planning and enhance the predictability of clinical outcomes. The comprehension gained from this research will contribute to the advancement of zygomatic implantology and help clinicians optimize treatment strategies for patients in South India and potentially other populations with similar anatomical variations.

MATERIALS AND METHODS:

Patients:

The study was conducted at the Saveetha Institute of Medical and Technical Sciences, department of periodontology and implantology. The research study received ethical approval from the Institutional Review Board and adhered to the ethical standards outlined in the 2013 revision of the 1975 Helsinki Declaration. The ethical clearance number was IHEC/SDC/PERIO-2102/22/176. The required statistical power of 90% was determined using G Power 3.0 software, and the sample size was determined based on the mean and standard deviation obtained from a previous study [19]. The CBCT images of 200 patients who were indicated for implant surgery were selected and examined. The samples included 102 males and 98 women, with ages ranging from 35 to 50 on average.

Exclusion and Inclusion Criteria:

The individuals who met the inclusion criteria for this study were: a) partially edentulous patients, both gender, who were advised to get a CBCT scan for procedures like implant placement, maxillary sinus augmentation, and those with osseous abnormalities; and b) patients aged between the ages of 30-50 years. The exclusion criteria for the study were as follows: Individuals with a history of trauma or pathological abnormalities affecting the maxillary sinus or zygoma, as well as those individuals whose CBCT scans showed distorted images of bone defects or artifacts.

CBCT Evaluation:

A CBCT scanner with a flat panel detector (the CS 9600 Carestream flat panel detector) was used for this study. The imaging parameters were set at 120 kV and 6.3 mA in accordance with the manufacturer's instructions. The exposure was 796 mGy/cm2 and the exposure period was 15 seconds. Utilizing the 3D image Light Carestream planning tool, the collected DICOM image data were imported and processed. A total of 200 CBCT scans were examined throughout the evaluation on several days in a dimly lit space. Low ambient lighting was maintained, and the diagnostic viewing screen was set up at a 60 cm distance. The most time allotted for per-day CBCT scan review did not extend 2 hours daily.

Parameters Assessed:

Lacunarity and prevalence of Pneumatization of Articular Eminence

The pneumatization of the articular eminence was evaluated, and the lacunarity of pneumatization was graded. According to Tyndall and Matteson [11], the lacunarity of pneumatization can be classified as unilacunar, which refers to a single, well-defined radiolucent small cavity, or multilacunar, which indicates the presence of multiple small cavities. Following the classification proposed by Al-Faleh and Ekram [20], the degree of pneumatization on both the left and right sides was categorized into four grades. Grade 0 represents pneumatization limited to the mastoid process only, Grade 1 indicates pneumatization between the mastoid process and the glenoid fossa, Grade 2 signifies pneumatization between the deepest point of the glenoid fossa and the tip of the articular eminence, and Grade 3 denotes pneumatization extending beyond the crest of the articular eminence as seen below (figure.1).

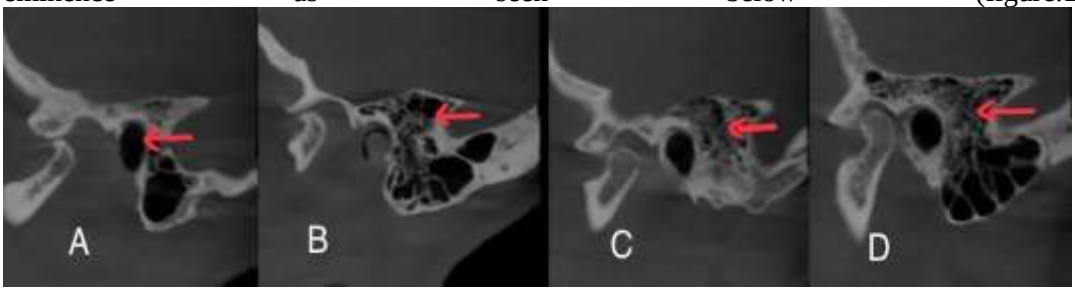

FIGURE. 1- Illustrates the various grading of pneumatisation of articular eminence (from A to D: grade 0, grade 1, grade 2 , grade 3).

Distance measured from crest of 1st molar to Zygoma

Measurements were made from the crest of first molar region to the zygoma to establish the accessible length for placement of zygomatic implant. An arbitrary radiopaque line was randomly drawn on the palatine surface of the remaining alveolar bone, 5 mm from the crest of the alveolar ridge, close to the first molar, for each implant location. The measurements followed this line as a guide [21]. It was stretched until it reached the zygoma. Bilateral measurements were taken to determine the length on both the right and left sides as seen below (figure.2).

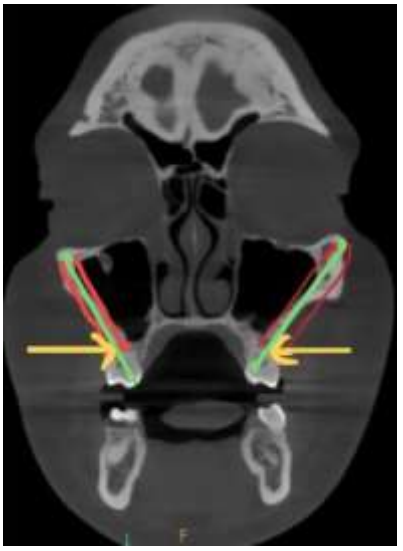

FIGURE.2- Illustrates the distance measured from the crest of 1st molar teeth to zygoma
ZAGA grading

The grading of ZAGA (Zygoma Anatomy Guided Approach) were assessed and compared between gender. A consistent classification developed by Carlos Aparicio was used to assess the ZAGA grading [7].

The following is the sequence of ZAGA grades:

- ZAGA 0: The anterior maxillary wall is extremely flat.
- ZAGA 1: The anterior maxillary wall has a modest concavity.
- ZAGA 2: reveals a concave anterior maxillary wall.
- ZAGA 3: The anterior maxillary wall demonstrates a highly concave contour.
- ZAGA 4: Describes a severe level of vertical and horizontal atrophy in both the maxilla and alveolar bone as shown below (figure.3).

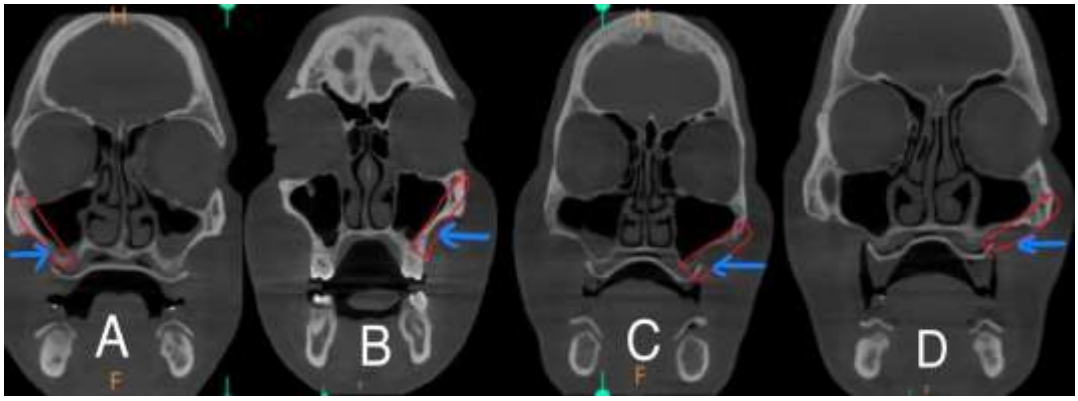

FIGURE.3- Illustrates Grading of ZAGA classification (from A to D: grade 0, grade 1, grade 2, grade 3)

RESULTS

The study included 200 participants, 102 of whom were males (51%), and 98 of whom were females (49%).The statistical analysis for this study was done using the specified version of IBM Corp.'s SPSS version 23 program. The data was summarized by calculating the mean and standard deviation. The normality of the data distribution was assessed using the Shapiro-Wilk test.

Lacunarity and Prevalence of Pneumatization of Articular Eminence

There was no statistically significant variation in the distribution of PAT grading between the gender and also between the same gender in terms of the right and left sides. However, there was a high frequency of grade 1 PAT in males and grade 2 PAT in females respectively. Descriptive statistics of the study participants were demonstrated in table 1.

Grade of PAT	0	1	2	3
Male	11(5.45%)	67(32.41%)	16(8.1%)	8(5.45)
Female	7(3.21%)	14(7.1%)	65(33.5%)	12(6.21%)
Total	23(11.5%)	78(39.1%)	87(43.5%)	18(9.1%)

Table 1- Illustrates the comparison of grading of pneumatisation between gender

There was no significant relationship between gender and the distribution of lacunarity between males and females. Multilacunar was highly prevalent in both males and females as seen below (figure.4).

Figure 4- Illustrates the comparison of lacunarity of articular eminence between gender

Distance measured from the crest of 1st molar to zygoma

There was a statistically significant difference observed between males and females in terms of the distance measured from the crest of the first molar to the zygoma. However, no significant difference was found in relation to right and left side within the same gender. The independent t-test was employed to compare the mean values of distance between males and females, while the student t-test was used to compare the right and left sides within the same group. Comparative analysis of the distance between males and females for each side were presented below (table 2 and figure.5).

GENDER	RIGHT SIDE Mean ± SD	LEFT SIDE Mean ± SD	p value(within the groups)
Male (n=102)	44.4± 1.38	44.± 1.39	0.08
Female (n=98)	40.37± 0.48	40.56± 0.49	0.1
p* value (between the groups)	0.001*	0.01*	

Table 2- Illustrates the comparison of distance measured from crest of 1st molar to zygoma on right and left sides with regard to gender

SD= standard deviation; n= number of participants in each group; P= probability of occurrence; $p<0.05$ indicates statistical significance

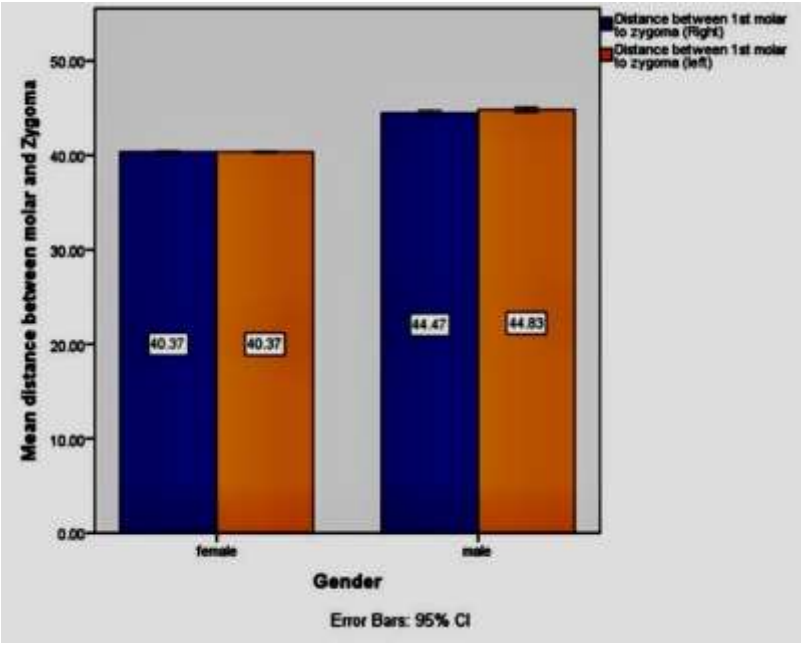

Figure 5 – Graphical representation illustrating the comparison of mean distance measured from crest of 1st molar to zygoma between gender

ZAGA grading

To examine the association between gender and ZAGA grading, a chi-square test was performed. ZAGA grading did not show any significant results within the same gender on each side ie right and left side. But there was a significant association between ZAGA grading and gender which was found by performing a chi-square test ($p<0.05$). It was observed that there was a high prevalence of ZAGA 1 among females and high prevalence of ZAGA 2 among males (Figure.6 and table 3).

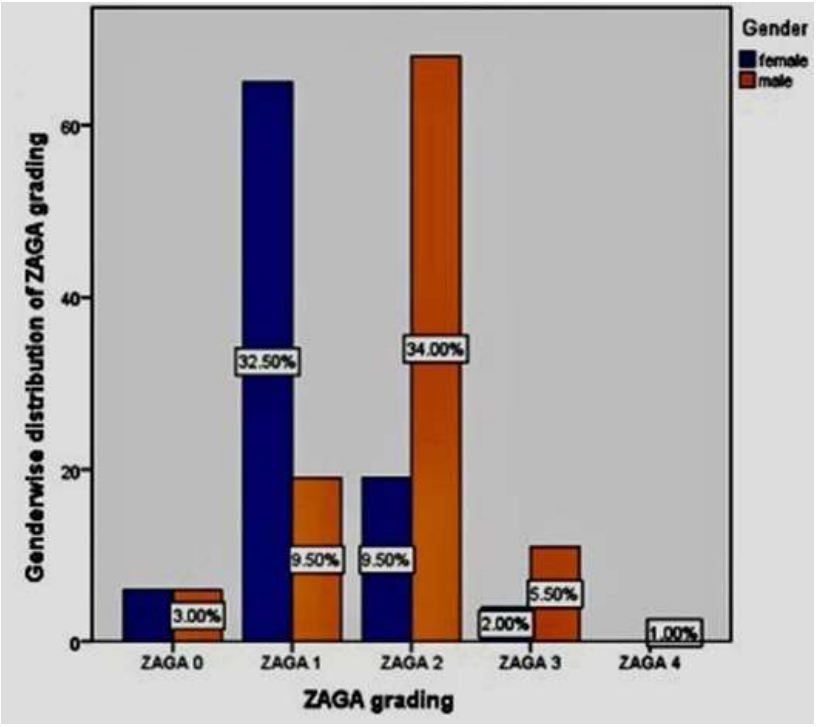

Figure 6- Graphical representation illustrating the comparison of grading of ZAGA between gender

Table 3- Depicts the comparison of grading of ZAGA between gender

GRADING OF ZAGA	0	1	2	3	4
Male	6(3.12%)	18(9.50%)	71(34.1%)	6(5.5%)	1(1.01%)
Female	5(3.01%)	67(32.50%)	21(9.50%)	4(2.01%)	1(1.01%)
p value	p>0.05	p<0.000*	p<0.000*	p>0.05	p>0.05

p* value less than 0.005 indicates statistically significant in relation to grade 1 and grade 2 ZAGA grading in females and males respectively

DISCUSSION:

The present study's findings encompassed data pertaining to the occurrence, arrangement, and extent of air-filled cavities within the articular eminence of the temporal bone. The evaluation of ZAGA grading and the measurement of bone length from the first molar crest to the zygoma were assessed in the study's outcomes. Several diagnostic techniques, such as simple film radiographs [22], CBCT [22], and CT [23], have been suggested in the past for the diagnosis of temporal bone pneumatization. To evaluate temporal bone pneumatization, two-dimensional radiographs such reverse towns, submentovertical radiography, and panoramic radiography have historically been used. However, these radiographs have inherent defects that cause the visibility of PAT to be insufficient, which reduces the precision of these modalities. In order to analyze pneumatized air spaces, three-dimensional images without superimposition are regarded as the gold standard. CBCT images offer improved spatial resolution, reduced artifacts, and high-quality visualization of the temporal bone. They provide high-resolution images with minimal artifacts, faster scanning time, and minimal radiation exposure. Therefore, in the present study, CBCT was utilized as the imaging modality to assess image quality.

It is crucial to comprehend the anatomical pathophysiology of the air cells near to the TMJ. The pneumatized articular eminence can complicate surgical procedures by decreasing bone resistance, which can result in unintentional penetration, and it may enhance the spread of inflammation, tumors, and fractures deep inside the bone, making implant placement challenging. No statistically significant disparities were observed between the right and left sides in the distribution of articular eminence pneumatization among both male and female participants. However it was as follows in males; grade 0=5.45%, grade1= 32.41%, grade 2= 8.1%, grade 3= 5.34% and in females it was; grade 0= 6.21%, grade 1= 7.1%, grade 2= 33.5%, grade 3= 6.9% respectively. As a result, grade 1 and grade 2 PAT were more prevalent, while grade 0 and grade 3 PAT were less prevalent. Grade 1 was more prevalent in males and grade 2 PAT was more prevalent in females. Nonetheless, no significant association was found between gender and pneumatization of the articular eminence (PAT). This was in agreement with earlier studies [3,19]. On the other hand, it was observed a slight predilection for the male gender with respect to the total of patients with PAT evaluated with CBCT [13]. In another study, Orhan et al. found that PAT was more prevalent in females than males in a Turkish population [24]. Furthermore, there was no statistically significant difference in PAT between the right and left sides. The variance and diversity in studies that employed the same CBCT method could be attributed to sample size differences and racial differences in the population investigated.

The current study also investigated the lacunarity of PAT in males and females on both the right and left sides. Both genders exhibited a notable prevalence of multilacunar PAT on both sides. However, no statistically significant correlation was found between gender and PAT lacunarity. Multilacunar PAT accounted for 32% each among males and females respectively. Unilacunar PAT accounted for 21% and 15% among males and females respectively. These findings are consistent with previous study conducted on the Iranian population [25].
The present study specifically targeted the Dravidian population, encompassing individuals from South India who speak Tamil, Malayalam, Telugu, and Kannada languages. To the best of the author's knowledge, this is the inaugural research employing CBCT to assess the

distance between the crest of the first molar and the zygoma within a South Indian community. The South Indian Population has diverse anatomic variations and ethnicities. In the present study, the mean distance in the right side among males and females was 44.4±1.38 mm and 40.37±0.48 mm respectively. The mean distance in left side among males and females was 44.8±1.39 mm and 40.37±0.48 respectively. The results revealed a statistically significant disparity (p=0.01*) in length between males and females on both the right and left sides. This was in agreement with a study done in brazilian and belgium population done by Rigolizzo et.al where similar results were shown done using CT scan [26]. These studies measured the length between dentate and edentulous patients and proved that there were significant results between the groups with regard to gender. Owing to the above study, the current study was done to arrive at appropriate conclusions and to assess the inter-individual variability among the partially edentulous patients with atrophic maxillae.

The present study included an assessment of ZAGA grading, revealing the following distribution: ZAGA 0 accounted for 3% in both males and females, ZAGA 1 for 32.5% in females and 9.50% in males, ZAGA 2 for 9.50% in females and 34.1% in males, and ZAGA 4 for 1% in both males and females. It was observed that ZAGA 1 was more prevalent among females, while ZAGA 2 was more prevalent among males. These findings not only contribute to the evaluation of inter-individual anatomical variations but also aid in the assessment of intra-individual differences between the right and left sides. The identification of an appropriate intraoral coronal entrance point at the alveolar process is a critical factor for achieving successful outcomes in the ZAGA procedure [22]. This grading is essential to decide between extra sinus and intra sinus pathways before placing zygomatic implants in resorbed atrophic maxilla [27-28]. This helps in avoiding complications like sinusitis and penetration into anatomical structures like infratemporal fossa. As a result, determining the bone length and the path of insertion of the implant(extra sinus or intra sinus) ie. ZAGA grading can be advantageous and beneficial before placing zygomatic implants.

The limitation of the research could be timeframe of the study. The study was conducted within a specific period, the prevalence and characteristics of articular eminence pneumatization and bone swatch for zygomatic implants may vary over time. The bone changes in an individual vary over age and time. Therefore timeframe of the study was not mentioned.

CONCLUSION:

It can be concluded from the study's limitations that pre-surgical examination for highly atrophic resorbed posterior maxillary ridges, CBCT assessment is essential for judicious evaluation and cautious treatment planning to avoid fatal consequences both during and after surgery. A key factor in the effectiveness of zygomatic implants is determining the length of accessible bone from the first molar to the zygoma, the distribution of pneumatization of the articular eminence, and the direction of insertion in accordance with the anatomy of the maxillary sinus wall.

CONFLICT OF INTEREST

None.

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