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**“VIRTUAL EXPLORATION OF PATH OF  
ZYGOMATIC IMPLANT PLACEMENT IN  
RELATION TO LATERAL WALL OF MAXILLARY  
SINUS - A CBCT BASED STUDY”**

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**By**

**REG NO. IG0221003**

*Dissertation*

*Submitted to the*

*KLE Academy of Higher Education & Research Belagavi, Karnataka*

*In partial fulfillment of the requirements for the degree of*

**MASTER OF DENTAL SURGERY  
IN  
ORAL MEDICINE AND RADIOLOGY  
(BRANCH-VII)**

**DEPARTMENT OF ORAL MEDICINE AND RADIOLOGY,  
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INSTITUTE OF DENTAL SCIENCES, JNMC CAMPUS,  
NEHRU NAGAR, BELAGAVI - 590010, KARNATAKA.**

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**2021 - 2024**

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Institution**

This is to certify that this dissertation / thesis entitled “**VIRTUAL EXPLORATION OF PATH OF ZYGOMATIC IMPLANT PLACEMENT IN RELATION TO LATERAL WALL OF MAXILLARY SINUS - A CBCT BASED STUDY**” is a bonafide research work carried out by **REG NO. IG0221003**.

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I, **REG NO. IG0221003**, Post Graduate student in the subject of Oral Medicine and Radiology have completed dissertation / thesis entitled “**Virtual exploration of path of Zygomatic implant placement in relation to lateral wall of Maxillary Sinus - A CBCT based study**” in the year 2024

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## LIST OF ABBREVIATIONS

<u>ABBREVIATION</u>	<u>FULL FORM</u>
<b>CBCT</b>	Cone Beam Computed Tomography
<b>CT</b>	Computed Tomography
<b>PSAA</b>	Posterior Superior Alveolar Artery
<b>mm</b>	Millimeters
<b>kVp</b>	Kilovoltage peak
<b>mA</b>	Milliampere
<b>ZAGA</b>	Zygoma Anatomy Guided Approach
<b>BIC</b>	Bone to Implant Contact
<b>3 D</b>	3 Dimensional
<b>SICAT</b>	SICAT Suite dental software
<b>SPSS</b>	Statistical Package for the Social Sciences
<b>COVID</b>	Coronavirus disease

## **ABSTRACT**

### **BACKGROUND:**

Dental implants today are the most reliable replacement of a missing teeth due to the property of osseointegration. However in some patients with poor alveolar bone, dental implants cannot be placed. Various methods of bone grafting has been given but Zygomatic implants have become a promising alternative because it acquires anchorage from Zygomatic bone. Zygomatic implant placement can have either intra-sinus or extra-sinus pathway based on shape of lateral wall of maxillary sinus.

### **AIM :**

To assess Virtual Zygomatic implant placement pathway in relation to shape of lateral wall of maxillary sinus.

### **OBJECTIVE :**

To assess placement of Virtual Zygomatic implant - Extra-sinus or Intra-sinus in relation to shape of lateral wall of maxillary sinus.

### **MATERIALS AND METHODS :**

140 CBCT (Cone Beam Computed Tomography) scans with FOV 17×13 between age 30 to 60 years, fulfilling the inclusion and exclusion criteria were included in this study. Virtual Zygomatic implant placement was done with respect to 25 using Sidexis software and Noble Biocare Zygoma 45° implant from implant library. Data regarding the shape of lateral wall of maxillary sinus and its relation to

Zygomatic implant placement was assessed by 2 examiners, tabulated and statistically analyzed.

### **RESULTS :**

82 scans had convex lateral wall of maxillary sinus, out of which 56 (68.29%) had intra-sinus implant placement pathway and 58 scans had concave lateral wall of maxillary sinus, out of which 52 (89.66%) had extra-sinus path of zygomatic implant. Inter examiner agreement was 95.71 % with  $k = 0.9126$  (  $p$  value  $< 0.05$ ).

### **CONCLUSION :**

Shape of lateral wall of maxillary sinus has significant relation in extra-sinus or intra-sinus placement of Zygomatic Implant which aids in precision planning of Zygomatic implants and better prognosis.

### **KEY WORDS :**

Shape of lateral wall of maxillary sinus, Intra-sinus / Extra-sinus pathway , Zygomatic implant, Cone Beam Computed Tomography.

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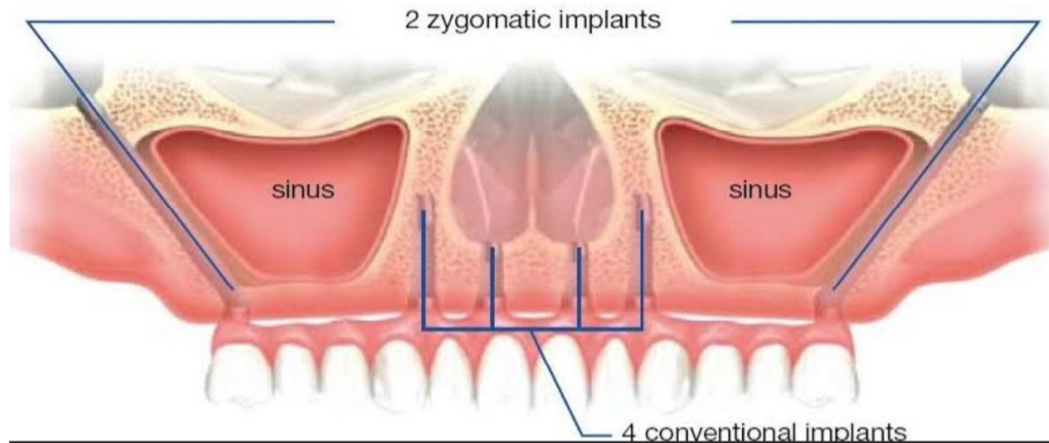
## INTRODUCTION

Dental implants today are one of the most common dental treatment modalities for replacement of missing teeth but it cannot be placed in absence of adequate bone as will compromise the stability of the implants. For many years now, bone grafting prior to implant placement has become a routine in conventional implant planning<sup>[1]</sup>. However, bone grafting procedures have risk and complications associated like morbidity at donor site and time taken in the procedure. Despite the literature available, the success with these grafting procedures is controversial as failure rates are higher in grafted maxilla than not grafted <sup>[1]</sup>

Zygomatic implants were introduced by Branemark in 1988, which obtain a firm anchorage from Zygomatic bone and is very effective alternative to grafting procedures<sup>[2]</sup>. Zygomatic bone is pyramidal in shape with mean length of 14 mm available for bone engagement which has proved to provide successful rehabilitation, restored function, improved aesthetics and helped patients to lead a normal social life<sup>[3]</sup>. Studies have shown that irrespective of alveolar bone atrophy, the bone engagement provided by Zygomatic bone to Zygomatic implants is constant i.e.  $0.19 \pm 0.06 \text{ cm}^{2, [5]}$  **Balshi et al** evaluated mean intra-malar length  $16.95 \pm 4.73 \text{ mm}$  and multivariate analysis suggested that the dental status and gender has no significant effect on maxillary sinus wall thickness<sup>[26]</sup>. However, this placement of the zygomatic implant needs evaluation to know the relationship to shape of lateral wall of maxillary sinus.

3-dimensional evaluation in Oral Radiology is done using CBCT. Field of view available for CBCT scans are  $5 \times 5$ ,  $8 \times 8$ ,  $11 \times 10$  and  $17 \times 13$  with Voxel size

ranging from 0.2 mm to 0.4 mm. Dental implant sites are frequent indications for Cone Beam Computed Tomography as it has high level of spatial resolution and thus helps in precision planning<sup>[9]</sup>.



The maxillary sinus is a three sided pyramid. Sinus lift is a surgery proposed to overcome challenges associated with maxillary sinus but sometimes changes in mucous membrane of maxillary sinus makes it impossible to do sinus lift procedures. Frequent complications associated were sinus membrane perforation, graft loss and graft infection<sup>[1]</sup>.

According to the conventional technique of placing Zygomatic implants, pathway taken by implant was intra-sinus and implant head emergence was on the palatal side of alveolar bone which resulted in complications like compromised prosthetic arch rehabilitation and silent sinus syndrome<sup>[4]</sup>. Virtual Zygomatic implant assessment using 3-D CBCT gives precise scans in 3 dimensions. This facilitates accurate planning, execution and follow up.

The literature review shows only one study that assessed Zygomatic implant placement pathway in relation to maxillary sinus based on alveolar bone atrophy<sup>[3]</sup>. Thus it was proposed to assess, Zygomatic implant placement pathway in relation to shape of lateral wall of maxillary sinus by placing Virtual Zygomatic implant in Cone Beam Computed Tomography scans using Sidexis software and Noble Biocare 45° implant from SICAT Suite implant library, according to anatomic insertion guidelines of Zygomatic implants by **Rossi et al**<sup>[15]</sup>.

## **HYPOTHESIS**

### **NULL HYPOTHESIS :**

The shape of Lateral wall of maxillary sinus does not have an effect on Zygomatic implant placement pathway.

### **ALTERNATIVE HYPOTHESIS :**

The shape of lateral wall of maxillary sinus does have an effect on Zygomatic implant placement pathway.

## **AIM OF THE STUDY**

To assess Virtual Zygomatic implant placement pathway in relation to shape of lateral wall of maxillary sinus.

## **OBJECTIVE**

To assess placement of Virtual Zygomatic implant in CBCT scans - Extra-sinus or Intra-sinus in relation to shape of lateral wall of maxillary sinus.

## **REVIEW OF LITERATURE**

### **Zygomatic Implants**

Zygomatic implants was first introduced by Branemark in 1988 which enabled surgeons to obtain anchorage from Zygomatic bone and made rehabilitation of atrophic maxilla possible post tumor resections<sup>[2]</sup>. However, the path of the Zygomatic implant placement was intra-sinus which resulted in implant head emergence on palatal aspect resulting in prosthetic arch malposition and chronic sinusitis<sup>[3]</sup>.

The maxilla was divided into 3 zones , The premaxilla as Zone 1, The premolar areas as Zone 2 and The molar area as Zone 3. Treatment recommendations were traditional (axial) implants in zone 1, 2 and 3, Four traditional implants (tilted) in zone 1 and 2, Zygomatic implants plus 2 or 4 traditional implants in zone 1 only and Four zygomatic implants in insufficient bone presence<sup>[1]</sup>

Zygoma Anatomy guided approach was given to overcome intra-sinus approach suggested by Branemark, which described anatomy guided implant placement pathway in relation to Zygomatic buttress - alveolar crest complex<sup>[4]</sup>. Clinical studies confirmed good outcomes with extra-sinus implant placement pathways with no obvious soft tissue irritation<sup>[11]</sup>.

### **MAXILLARY SINUS**

Maxillary sinus is present bilaterally in the maxilla. It is a pyramidal shaped cavity with 4 walls, anterior, lateral, superior and inferior. Scheneiderian membrane is the mucosal lining of the maxillary sinus. In chronic sinus inflammation, membrane

thickness is increased. It is first sinus to develop from 10 weeks of gestation and its extension into ossifying maxilla is seen at 20 weeks<sup>[15]</sup>.

Conventionally for endosteal implants, in order to increase the bone height, sinus lift procedures were performed but it was invasive and so, a crestal approach was given using osteotomes but limitation of this technique was that minimum of 6 mm of alveolar bone was needed for primary stability<sup>[1]</sup>. If not present, then bone graft has to be placed. The complications associated were sinus membrane perforation, graft loss and graft infection. Sinus lift procedure is contraindicated in patients with history of radiation therapy or iv bisphosphonates. Acute sinusitis and chronic periodontitis are considered as high risk factors. Therefore to avoid the complications, Zygomatic implants were encouraged<sup>[1]</sup>. To analyze the detection of PSAA in lateral wall of maxillary sinus, a meta analysis was done comparing conventional CT with CBCT . The study concluded that preoperative CBCT is more effective in detection of PSAA than CT<sup>[34]</sup>. Therefore, Cone Beam Computed Tomography today provides the highest level of precision in dentistry.

**Carlos aparacio et al (2000)** gave zygomatic implants indications, techniques and outcomes. The aim of their study was to overview the conventional grafting technique, review the alternative technique i.e. Zygomatic implants and report success of rehabilitation with Zygomatic implants. The conclusion of the study was failure of 10-30% cases after grafting procedures, Zygomatic implants improved the clinical results and possible gold standard for patients with maxillary bone atrophy and regarded CBCT as an appropriate tool for assessing placement of Zygomatic Implant. Also it was concluded in the study that if the implant can be placed extra-sinus, there

will be fewer sinus complications with reduced oro-antral communication and better position for prosthetic rehabilitation.

**Yuki Uchida et al (2001)** conducted a study on maxilla and zygoma measurements to acquire information on installation of Zygomatic implants . Angular and linear distance was measured between Zygoma and maxilla and concluded that the installation angle of Zygomatic implants between 43.8° to 50.6°. When the angle is less than 43.8, perforation of maxilla, zygoma and infratemporal fossa should be avoided and if angle is greater than 50.6, perforation of orbital floor should be avoided.

**Carlos aparicio et al (2008)** studied use of Zygomatic implants in severely resorbed maxilla for prosthetic rehabilitation and reported soft tissue complications in the maxillary sinus. 31 implants had to be removed secondary to sinus inflammation although the implants were firm on clinical examination. 9 implants presented with peri implantitis because of difficulty in maintaining oral hygiene due to intra-sinus pathway leading to prosthetic arch malposition. Therefore the risk of sinusitis and soft tissue complications should not be underestimated.

**Lutz Ritter et al (2011)** undertook a study to assess maxillary sinus using Cone Beam Computed Tomography , 1099 scans were retrospectively studied and concluded that pathologies of maxillary sinus can be accurately detected using CBCT images.

**Carlos aparicio (2014)** introduced a classification based on Zygoma Anatomy Guided approach (ZAGA) and the classification given comprised of 5 groups ( ZAGA 0-4) which can be further used for categorizing Zygomatic implant cases.

**L. -F. Pu et al (2014)** analyzed age related changes in bases of Zygoma and maxilla. The study comprised of 40 subjects in edentulous group and dentulous group had 120 subjects. The study concluded that antero posterior length was thicker in older dentate patients but difference in these thickness was not significant between elderly dentate and edentulous groups.

**Saeedeh Khajehahmadi et al (2014)** evaluated association between dental status and maxillary sinus wall thickness using Cone Beam Computed Tomography. The objective of the study was determining if there are any changes in maxillary sinus wall thickness secondary to tooth extraction. The study concluded that there is no significant effect of gender and dental status on thickness of lateral wall of maxillary sinus. ( $p > 0.05$ ).

**Amani Ayman Mohamed et al (2020)** in their cross sectional study used CBCT to assess variations in maxillary sinus septa of Egyptian population. 111 CBCT scans of maxillary sinus were evaluated and concluded prevalence of septa in 33% of the sample. Thus reporting the importance of preoperative planning using CBCT.

**Marcelle Rossi et al (2020)** conducted a study to understand anatomic bases for Zygomatic implant placement . Linear and angular measurements were done on 40 dry skulls from maxilla to zygoma and concluded installation angle of Zygomatic implant is between  $39^\circ$  and  $62^\circ$ . If the installation angle is less than  $39^\circ$ , will lead to perforation in zygoma, maxilla and infratemporal fossa and if greater than  $62^\circ$ , there is risk of orbital floor perforation.

**Syed Irshad Ahmed et al (2020)** in his case report took into account the rehabilitation of atrophic maxilla using extra-sinus approach of Zygomatic implants.

Noble Zygoma implants were used and there were no reports of sinusitis and oro-antral fistula as the path taken by the Zygomatic implants was extra-sinus and concluded that Zygomatic Implants are very good alternative for rehabilitation with high success rates.

**Neelam Manoj Vaibhav et al (2021)** in their study on postmenopausal women in evaluation of zygomatic bone for placement of 4 zygomatic implants using Cone Beam Computed Tomography. 120 CBCT scans of females from age between 45-65 yrs were assessed and concluded that posteriosuperior region and center of Zygoma are superior places for placement of Zygomatic Implants.

**Paweł Aleksandrowicz et al (2022)** studied 12 year follow up after placement of zygomatic implants. In 22 patients, 35 Zygomatic implants were placed with 24 implants having intra-sinus and 11 having extra-sinus pathway. Follow up period was 50 months to 152 months and concluded chronic sinusitis and malposition of prosthetic arch as a complication in 4 patients with intra-sinus path of implant placement and no patients with extra-sinus Zygoma developed any complication. Also the extra-sinus placement of Zygomatic implant provides greater BIC (Bone-to-Implant Contact) increasing stability of the implant.

## **METHODOLOGY**

### **STUDY DESIGN :**

Cross sectional study .

### **SOURCE OF DATA :**

140 Cone Beam Computed Tomography scans which are taken for diagnostic and treatment purpose of Field of View 17×13 with a Axiom Densply Sirona Cone beam 3D Imaging machine, fulfilling the inclusion and exclusion criteria were included in the study by convenience sampling from archives of Department of Oral Medicine and Radiology, KLE V.K. Institute of Dental Sciences, Belagavi, Karnataka.

### **ARMAMENTARIUM :**

1. Axiom Densply Sirona Cone Beam 3D imaging machine
2. Sidexis software to view the CBCT scans
3. SICAT suite software for implant planning
4. Excel Sheets for recording the observations.

### **SELECTION CRITERIA :**

#### **Inclusion criteria:**

1. CBCT scans of patients between 30-60 years.
2. CBCT scans with sound Zygomatic bone.
3. CBCT scans without alveolar bone atrophy.

**Exclusion criteria :**

1. CBCT scans with Zygomatic bone atrophy
2. CBCT scans with maxillary sinus opacifications.
3. CBCT scans with prior placement of conventional implant with respect to 25.

**METHOD :**

140 CBCT scans with Field of View 17×13, fulfilling the inclusion and exclusion criteria taken with Axios Densply Sirona CBCT machine with exposure settings of 85 kVp, 12 mA as shown in figure 1 were obtained by convenience sampling from archives of Oral Medicine and Radiology Department.

The scans were exported to SICAT suite software for Virtual Zygomatic Implant placement using Nobel Biocare 45° implant from implant library with respect to 25. By placing the inspection window in the 25 region in panoramic view, implant planning was assessed in all the views, i.e. sagittal, cross sectional and axial view. Virtual Implant placed was examined by a trained radiologist.

**Implant planning and assessment :**

Sidexis 4 dental systems software was used to view the CBCT scans. Implant planning was done in SICAT suite implant planning software.

The mast limits for placement of Zygomatic implants were set as follows indicating the placement of Zygomatic implants between these limits.

1. Coronal plane :

Anterior limit - Anterior nasal spine.

Posterior limit - Distal to pterygoid plates.

2. Axial plane :

Cranial limit - Nasion

Caudal limit - Inferior to alveolar crest of upper maxilla.

Virtual implant planning was done as shown in figure 2-8.

One Zygomatic implant was virtually placed with respect to 25 engaging the center of Zygoma according to anatomical insertion guidelines by **Rossi et al** and **Rigolizzo et al** .

Zygoma 45° implant was chosen for installation as it's the most preferred installation angle between 43.8° and 50.6° as suggested by **Yuki Uchida et al (2001)**. Adequate implant length was selected to engage the center of Zygomatic bone. Zygomatic implant placed was assessed in all the planes i.e. sagittal, cross sectional and axial.

**STATISTICAL ANALYSIS :**

The shape of lateral wall of the maxillary sinus and pathway taken by the Zygomatic implant were entered in Microsoft Excel software. Windows software SPSS 21.0 was used to carry out statistical analysis. Qualitative variables were expressed as number and percentage. Mc Nemar chi-square test was done to compare 2 different parameters i.e. shape of lateral wall of maxillary sinus and Zygomatic implant placement pathway. Inter examiner reliability was done by Cohen's Kappa statistics. The level of significance was kept at 5%. ( $p < 0.05$ ).

**PHOTOGRAPHS**



**Figure 1. Axelos Densply Sirona CBCT Machine**

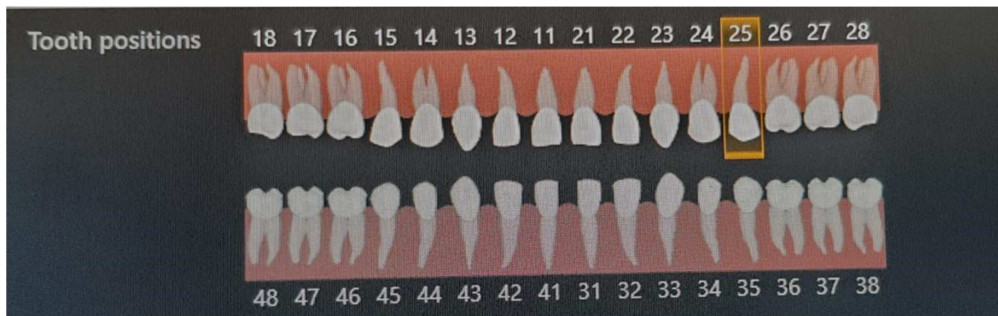


Figure 2. Selection of 25

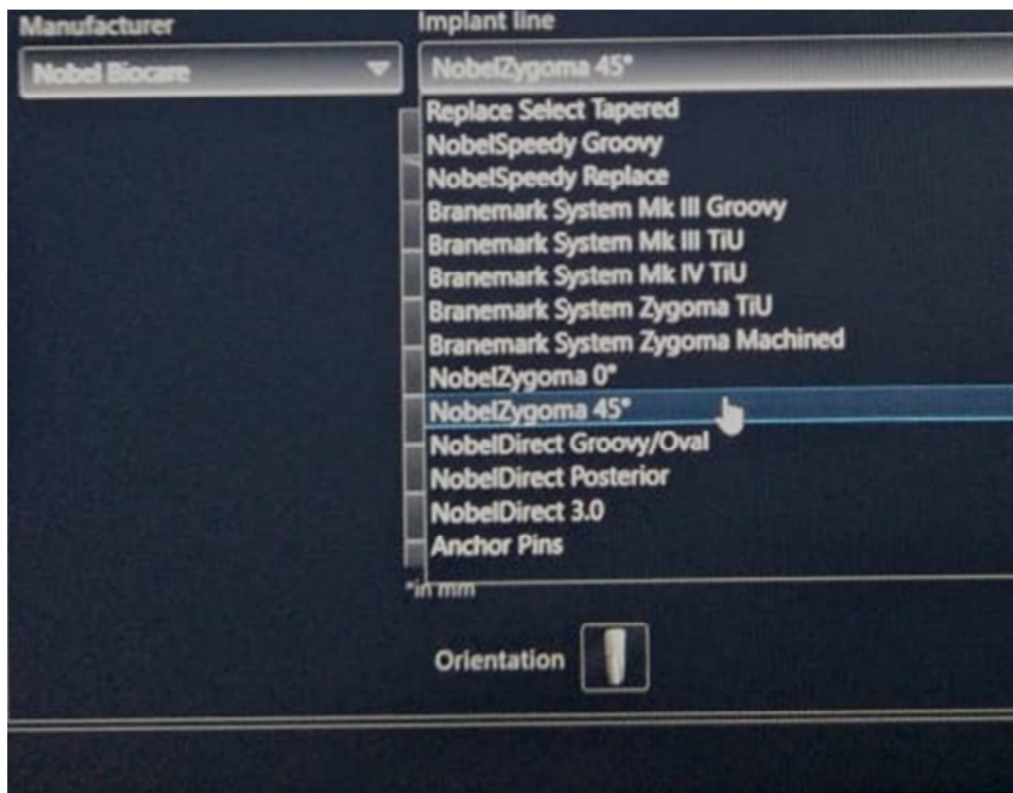


Figure 3. Selection of Noble Zygoma 45° from Implant library

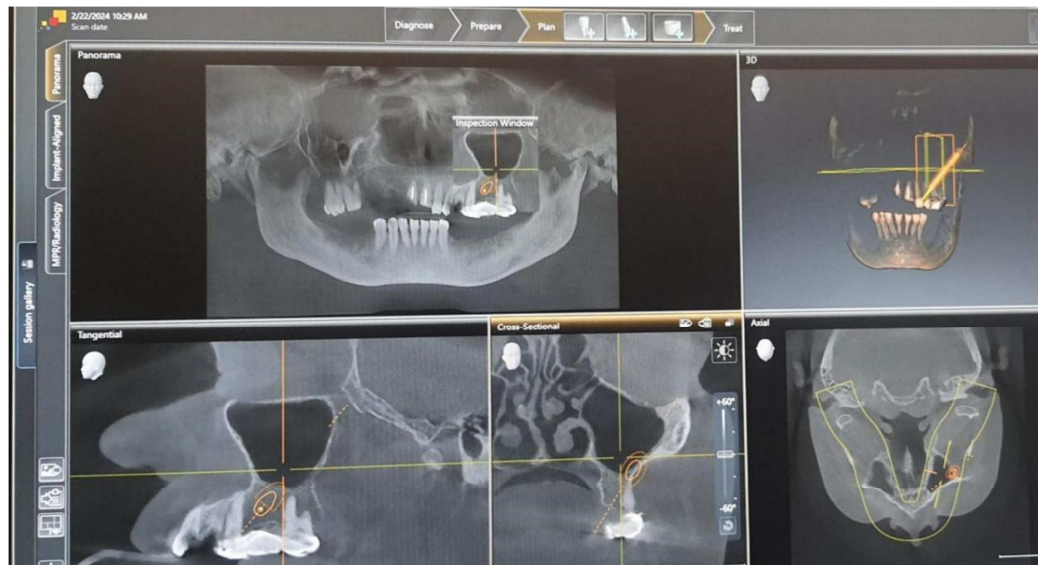


Figure 4. Placement of Zygomatic Implant

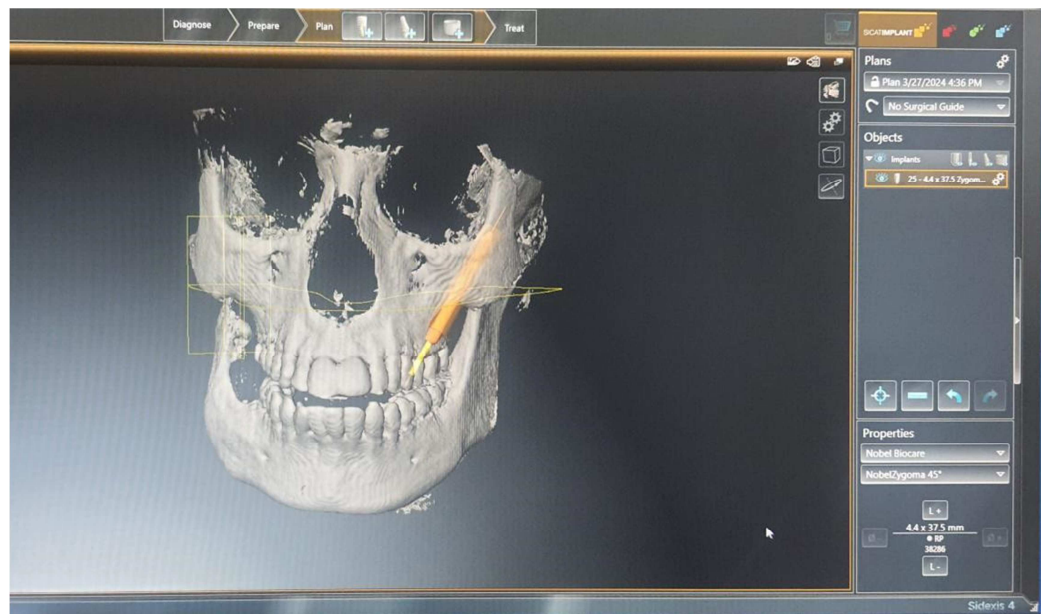
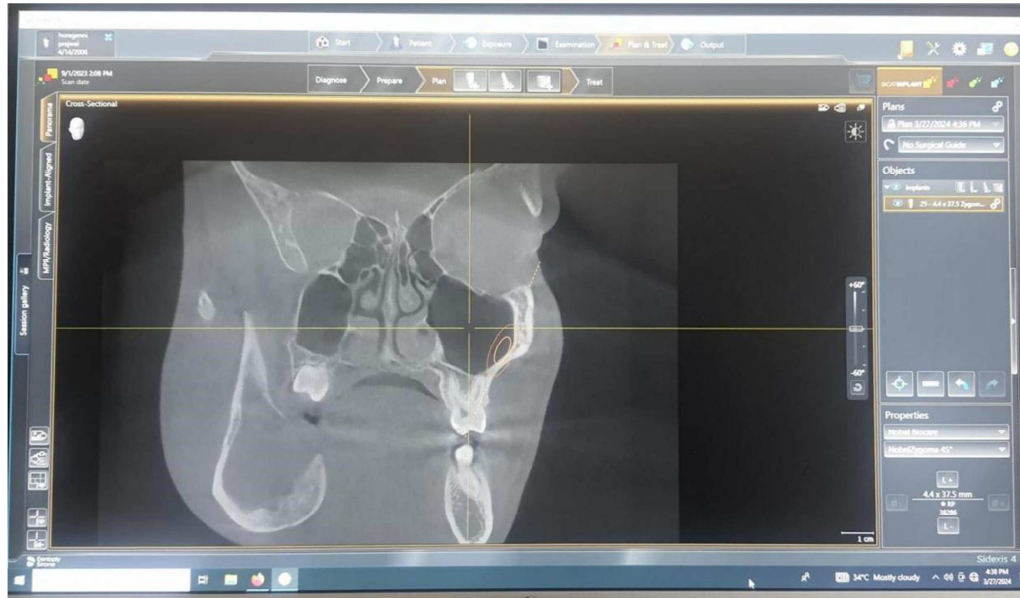


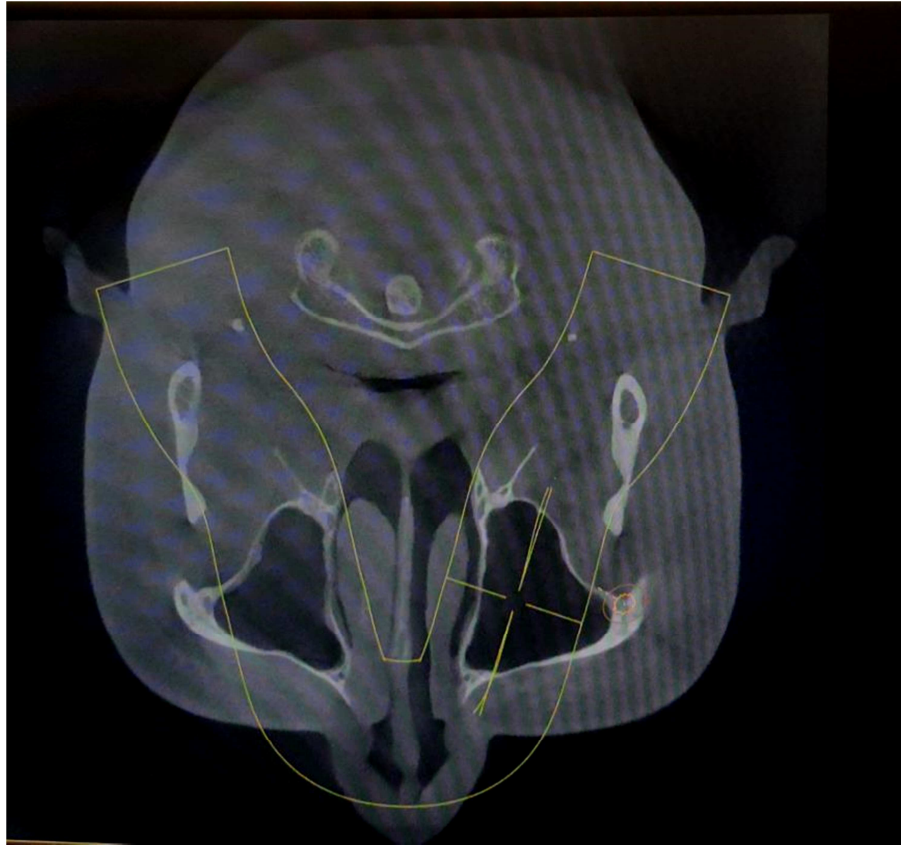
Figure 5. 3-Dimensional view



**Figure 6. Cross sectional view with Intrasinus path of Zygomatic Implant**



**Figure 7. Cross sectional view with Extrasinus path of Zygomatic Implant**



**Figure 8. Axial view with Implant placed in Zygomatic bone**

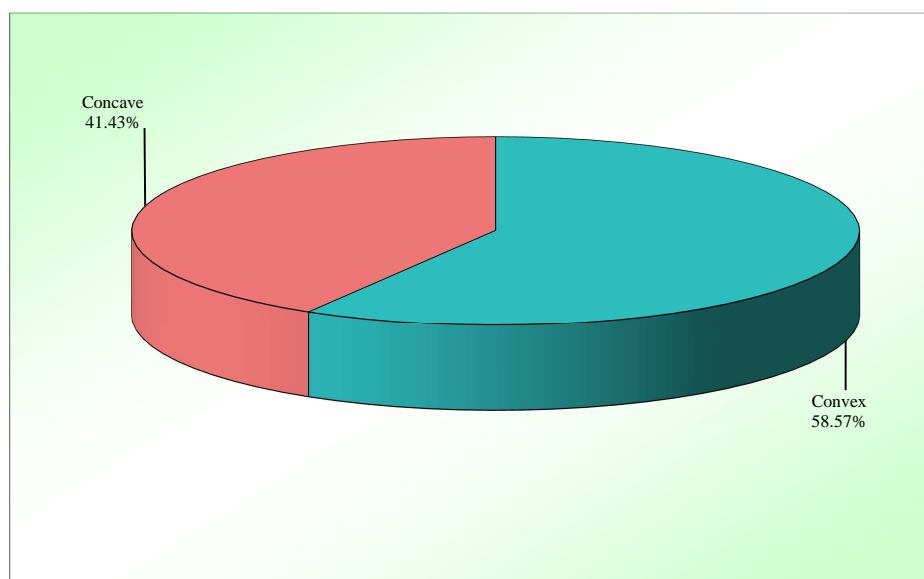
## RESULTS

140 CBCT scans were assessed in the study. Percentage wise distribution according to stratus of outcome of lateral wall of maxillary sinus is depicted in Table 1 and Figure 1, and the stratus of outcome of Zygomatic implant pathway is depicted in Table 2 and Figure 2, Comparison of the outcome of Lateral wall of maxillary sinus and Zygomatic implant pathway is depicted in Table 3 and Figure 3.

**Table: 1 Stratus of outcome of lateral wall of maxillary sinus**

Lateral wall of maxillary sinus	Number	Percentage
Convex	82	58.57
Concave	58	41.43
Total	140	100.00

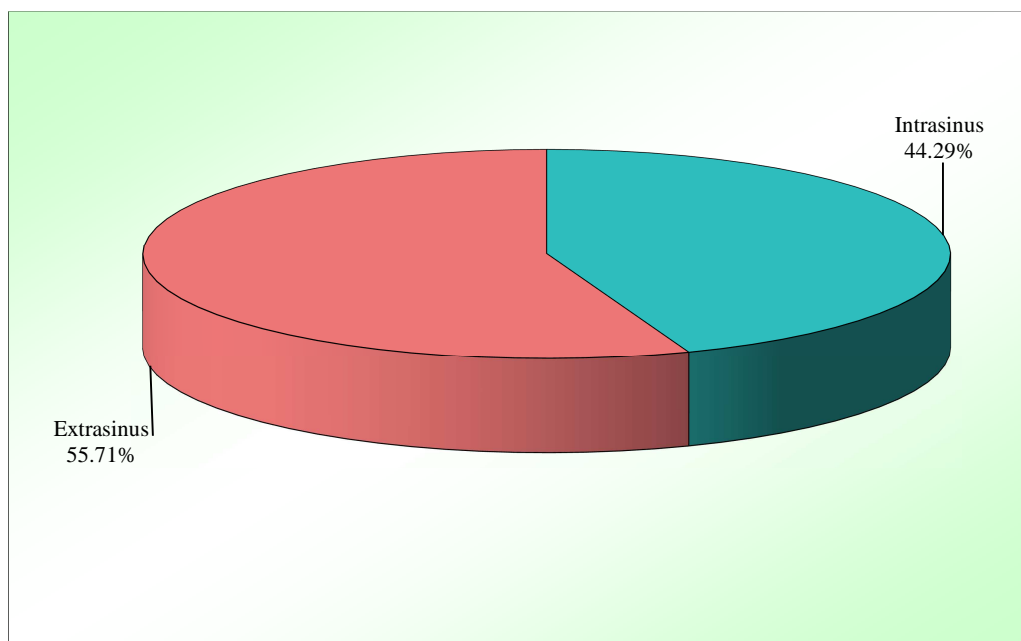
**Graph 1 : Stratus of outcome of lateral wall of maxillary sinus**



**Table 2: Stratus of outcome of Zygomatic implant pathway**

Zygomatic Implant pathway	Number	Percentage
Intrasinus	62	44.29
Extrasinus	78	55.71
Total	140	100.00

**Graph 2 : Stratus of outcome of Zygomatic implant pathway**



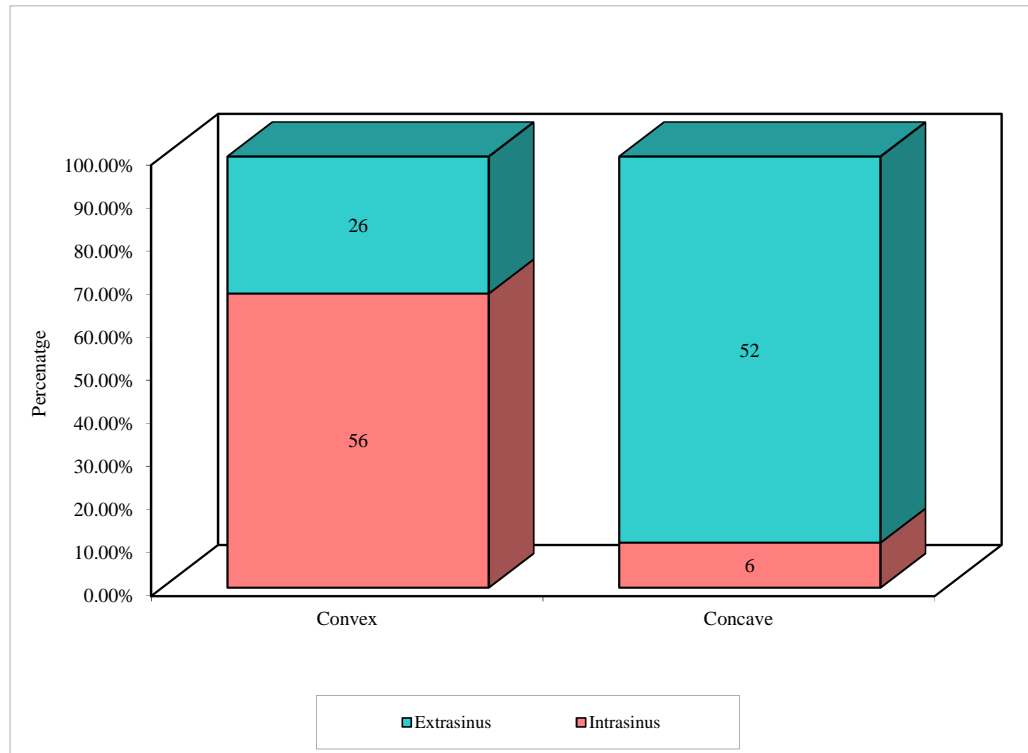
**Table 3 : Comparison of outcome of lateral wall of maxillary sinus and Zygomatic implant pathway**

Lateral wall of maxillary sinus	Zygomatic Implant pathway					
	Intra-sinus	%	Extra-sinus	%	Total	%
Convex	56	68.29	26	31.71	82	58.57
Concave	6	10.34	52	89.66	58	41.43
Total	62	44.29	78	55.71	140	100.00
Mc Nemar chi-square, p=0.0010*						

\*p<0.05

Mc Nemar Chi square test reveals that lateral wall of maxillary sinus has a significant relation ( $p = 0.0010$ ) to Zygomatic implant placement pathway. When the lateral wall of maxillary sinus was convex, 68.29 % Zygomatic implants had intra-sinus pathway and when lateral wall of maxillary sinus is concave, 89.66 % Zygomatic implants had extra-sinus path of implant placement.

**Graph 3: Comparison of outcome of lateral wall of maxillary sinus with Zygomatic implant pathway**



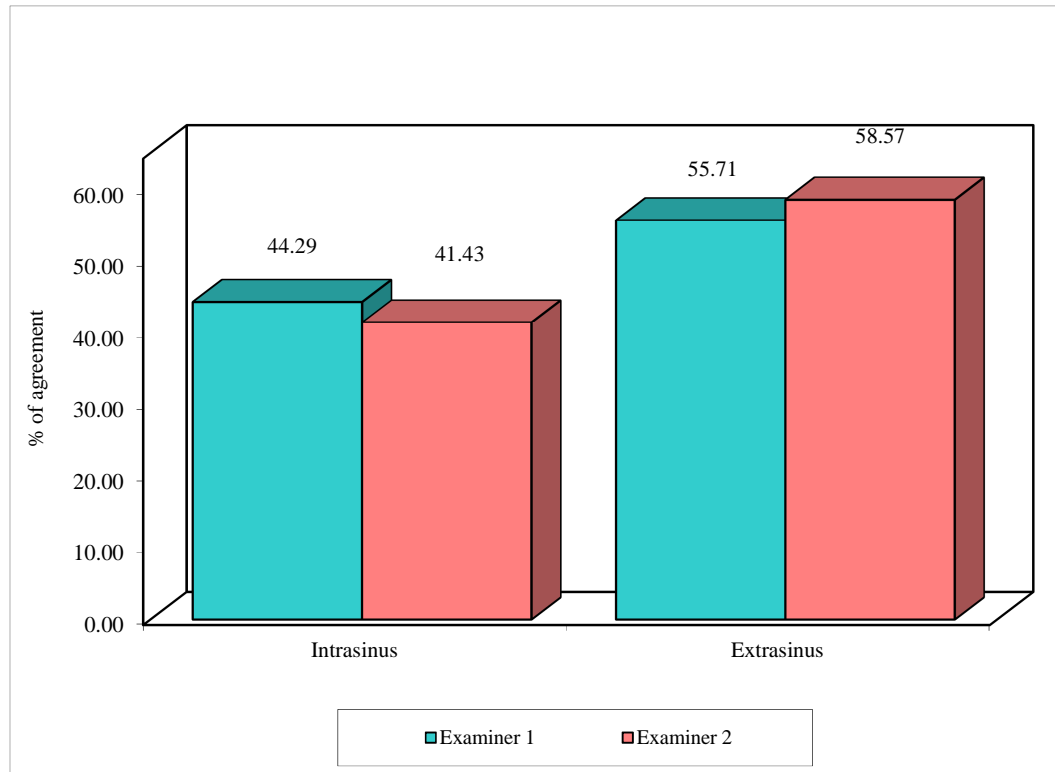
Cohen kappa statistics showed a reliable inter observer agreement ( $k=0.9126$ ) with statistically significant values ( $p < 0.05$ ) which is depicted in Table 4 and Figure 4

**Table: 4 Inter examiner agreement between two examiners in assessment of Zygomatic implant pathway**

Examiner 1	Examiner 2		Total	%
	Intra-sinus	Extra-sinus		
Intra-sinus	57	5	62	44.29
Extra-sinus	1	77	78	55.71
Total	58	82	140	100.00
%	41.43	58.57	100.00	
Agreement	Kappa	Std. Err.	Z-value	p-value
95.71%	0.9126	0.0844	10.8200	0.0001*

\* $p < 0.05$

**Graph 4: Inter examiner agreement between two examiners in assessment of Zygomatic implant pathway**



## **DISCUSSION**

Conventional implant placement came into existence to replace missing teeth and in order to achieve stability of the dental implants, a firm anchorage is required which should be provided by the adjacent bone<sup>[1]</sup>. Now a days, with increase in cases of diabetic patients in whom there is increased prevalence of periodontal problems, there is no adequate bone for implant placement<sup>[3]</sup>. Patients coming for tooth replacement after a prolonged period of extraction also present with alveolar bone resorption. Overcoming, the difficulty encountered due to resorbed maxilla, bone grafting was proposed as an alternative and is being used for more than 4 decades now<sup>[1]</sup>. Various techniques were given including on-lay bone grafting, all having the aim to increase the bone in the region of implant placement.

In spite of many techniques, there was immediate or delayed implant failure encountered with procedures involving bone grafting. Therefore, there was need for an alternative with long term success rates<sup>[48]</sup>.

Branemark introduced Zygomatic implants in 1988 to rehabilitate atrophic maxilla secondary to tumor resection and also in cases of congenital defects<sup>[2]</sup>. Zygomatic implants provide firm anchorage from Zygomatic bone. Post Covid 19 and mucormycosis, which lead to complete maxillary bone necrosis and subsequent resection, Zygomatic implants have given a ray of hope to patients to live a normal social life again with adequate rehabilitation of function and aesthetics<sup>[1]</sup>.

Conventionally the approach suggested by Branemark for placement of Zygomatic implants was intra-sinus pathway which has resulted in emergence of implant head on palatal aspect making it difficult to maintain oral hygiene<sup>[4]</sup>.

Therefore, later prosthetically driven Zygomatic implants were placed which solved the problem of prosthetic arch malposition<sup>[4]</sup>.

Intra-sinus pathway taken by the implants was other complication of Zygomatic implant placement which led to silent sinus syndrome and Oro-antral communication. These complications resulted in removal of implants due to recurrent sinusitis. Studies have shown that there is decrease in Bone implant contact (BIC) with intra-sinus path of Zygomatic implant placement, thus decreasing stability of Zygomatic Implants<sup>[4]</sup>. To avoid the known complications, best way is to assess how implant planning can be done using extra-sinus path before the surgery<sup>[11]</sup>. This can be assessed by using Cone Beam Computed Tomography which has a voxel size of 0.4 mm.

**Lutz Ritter et al** assessed maxillary sinus with the help of Cone Beam Computed Tomography. 1099 CBCT scans were retrospectively evaluated to identify mucosal thickening and opacification. It was reported that patients above 60 years were more prone to sinus pathologies and Cone Beam Computed Tomography could assess sinus anatomy and pathologies<sup>[10]</sup>.

Similarly, **Saeedeh Khajehahmadi et al** evaluated thickness of lateral wall of maxillary sinus using Cone Beam Computed Tomography and concluded that thickness of maxillary sinus in males is  $1.56 \pm 0.31$  and in females it was  $1.56 \pm 0.30$  with respect to 25, which was statistically insignificant<sup>[12]</sup>. Therefore, in our study we have chosen 25, as the area for placement of Zygomatic Implant.

Relationship of the Zygomatic Implant pathway to the sinus was assessed by **J. Bertos Quiñez et al** using Cone Beam Computed Tomography, sample size of 92 was considered, and 60.9 % implants had extra-sinus pathway and 44.1 % had intra-sinus pathway of Zygomatic implant and concluded that there was a significant relation between alveolar bone atrophy and pathway of Zygomatic implant placement, that when there is increase in alveolar bone atrophy, implant pathway is intra-sinus<sup>[3]</sup>. Similarly in our study 55.71% had an extra-sinus pathway of Zygomatic Implant placement and 44.29 % had an intra-sinus path of Zygomatic implant placement.

**Carlos aparacio et al** assessed the Zygomatic implant placement pathway in relation to the shape of the lateral wall of maxillary sinus and found that when the anterior maxillary wall is concave, the pathway taken by the Zygomatic implant was extra-sinus<sup>[4]</sup>. Similarly in our study, when the lateral wall was concave, 89.66% Zygomatic implant placement pathway was extra-sinus.

This proves that the morphology of lateral wall of maxillary sinus has a significant relation to Zygomatic Implant placement pathway.

## **LIMITATIONS OF THE STUDY**

- The study is not clinically correlated.
- Scans of patients below 30 years and above 60 years are not considered in this study.

## **FUTURE PROSPECTS OF THE STUDY**

1. The study can be clinically correlated.
2. Separate studies can be done for different age groups.
3. More number of sample size can be considered in future studies.

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ANNEXURE I

**ETHICAL CLEARANCE CERTIFICATE**



**Research and Ethics Committee  
KLE VK INSTITUTE OF DENTAL SCIENCES**

A Constituent Unit of KLE Academy of Higher Education & Research  
Accredited 'A' Grade by NAAC Placed in Category 'A' by MHRD (GoI)  
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**CERTIFICATE**

Sl. No. : **1585**

EC/NEWINST/2021/2435  
Research & Ethics Committee

*This is to Certify that the synopsis titled*

Virtual exploration of path of zygomatic implants  
placement in relation to lateral wall of maxillary sinus  
-ACBCT based study Submitted by

Dr. \_\_\_\_\_ P. G. Student /

Staff, Guided by \_\_\_\_\_ from Department of  
Oral Medicine and Radiology has been critically evaluated by  
committee members and granted ethical clearance to conduct the above  
mentioned study

Date : 3/4/24

**Member Secretary**  
Research and Ethics Committee  
KLEVK Institute of Dental Sciences  
Belagavi  
**MEMBER SECRETARY**  
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## ANNEXURE II

MASTER CHART - Assessment of pathway of Zygomatic Implant Pathway in relation to lateral wall of maxillary sinus by Examiner 1

Scan No.	Lateral wall of maxillary sinus	Virtual Zygomatic Implant pathway
1	convex	Extrasinus
2	convex	Intrasinus
3	concave	Extrasinus
4	convex	Intrasinus
5	concave	Extrasinus
6	convex	Intrasinus
7	convex	Intrasinus
8	convex	Intrasinus
9	convex	extrasinus
10	concave	Extrasinus
11	concave	extrasinus
12	convex	Intrasinus
13	convex	Intrasinus
14	concave	Extrasinus
15	concave	extrasinus
16	convex	intrasinus
17	concave	Extrasinus
18	convex	Intrasinus
19	concave	Extrasinus
20	convex	intrasinus
21	convex	Extrasinus
22	convex	Extrasinus
23	convex	Extrasinus
24	convex	Intrasinus
25	convex	extrasinus
26	convex	Intrasinus
27	concave	extrasinus
28	convex	Extrasinus
29	concave	Extrasinus
30	concave	Intrasinus
31	concave	extrasinus
32	concave	Extrasinus
33	concave	Extrasinus
34	convex	Extrasinus
35	convex	intrasinus

36	concave	Extrasinus
37	concave	Extrasinus
38	convex	intrasinus
39	convex	Intrasinus
40	concave	extrasinus
41	Convex	Intrasinus
42	Concave	Extrasinus
43	Convex	Extrasinus
44	Convex	Intrasinus
45	Convex	Extrasinus
46	Convex	Intrasinus
47	convex	Extrasinus
48	Convex	intrasinus
49	Convex	Intrasinus
50	Convex	Intrasinus
51	Concave	Extrasinus
52	Concave	Intrasinus
53	Concave	Intrasinus
54	Convex	Intrasinus
55	Concave	Extrasinus
56	Concave	Extrasinus
57	Concave	Extrasinus
58	Convex	Extrasinus
59	Concave	Extrasinus
60	Convex	Intrasinus
61	Convex	Intrasinus
62	Concave	Extrasinus
63	convex	Extrasinus
64	convex	Intrasinus
65	concave	Extrasinus
66	convex	Intrasinus
67	concave	Extrasinus
68	convex	Intrasinus
69	convex	Intrasinus
70	convex	Intrasinus
71	convex	extrasinus
72	concave	Extrasinus
73	concave	extrasinus
74	convex	Intrasinus
75	convex	Intrasinus
76	concave	Extrasinus
77	concave	extrasinus

78	convex	intrasinus
79	concave	Extrasinus
80	convex	Intrasinus
81	concave	Extrasinus
82	convex	intrasinus
83	convex	Extrasinus
84	convex	Extrasinus
85	convex	Extrasinus
86	convex	Intrasinus
87	convex	extrasinus
88	convex	Intrasinus
89	concave	extrasinus
90	convex	Extrasinus
91	concave	Extrasinus
92	concave	Intrasinus
93	concave	extrasinus
94	concave	Extrasinus
95	concave	Extrasinus
96	convex	Extrasinus
97	convex	intrasinus
98	concave	Extrasinus
99	concave	Extrasinus
100	convex	Intrasinus
101	convex	Intrasinus
102	concave	extrasinus
103	Convex	Intrasinus
104	Concave	Extrasinus
105	Convex	Extrasinus
106	Convex	Intrasinus
107	Convex	Extrasinus
108	Convex	Intrasi nus
109	convex	Extrasinus
110	Convex	intrasinus
111	Convex	Intrasinus
112	Convex	Intrasinus
113	Concave	Extrasinus
114	Concave	Intrasinus
115	Concave	Extrasinus
116	Convex	Intrasinus
117	Concave	Extrasinus
118	Concave	Extrasinus
119	Concave	Extrasinus

120	Convex	Intrasinus
121	Concave	Extrasinus
122	Convex	Intrasinus
123	Convex	Intrasinus
124	Concave	Extrasinus
125	convex	Extrasinus
126	convex	Intrasinus
127	concave	Extrasinus
128	convex	Intrasinus
129	concave	Extrasinus
130	convex	Intrasinus
131	convex	Intrasinus
132	convex	Intrasinus
133	convex	extrasinus
134	concave	Extrasinus
135	concave	extrasinus
136	convex	Intrasinus
137	convex	Intrasinus
138	concave	Extrasinus
139	concave	Intrasinus
140	convex	intrasinus

LATERAL WALL (140)	INTRASINUS	EXTRASINUS
<b>CONVEX (82)</b>	56	26
<b>CONCAVE (58)</b>	6	52

## ANNEXURE III

MASTER CHART - Comparison of Assessment of pathway of Zygomatic Implant

Pathway in relation to lateral wall of maxillary sinus by Examiner 1 and Examiner 2

Scan no.	Lateral wall of maxillary sinus	Virtual Zygomatic Implant pathway	
		Examiner 1	Examiner 2
1	convex	Extrasinus	Extrasinus
2	convex	Intrasinus	Intrasinus
3	concave	Extrasinus	Extrasinus
4	convex	Intrasinus	Intrasinus
5	concave	Extrasinus	Extrasinus
6	convex	Intrasinus	Intrasinus
7	convex	Intrasinus	Extrasinus
8	convex	Intrasinus	Intrasinus
9	convex	Extrasinus	Extrasinus
10	concave	Extrasinus	Extrasinus
11	concave	Extrasinus	Extrasinus
12	convex	Intrasinus	Extrasinus
13	convex	Intrasinus	Intrasinus
14	concave	Extrasinus	Extrasinus
15	concave	Extrasinus	Extrasinus
16	convex	Intrasinus	Extrasinus
17	concave	Extrasinus	Extrasinus
18	convex	Intrasinus	Intrasinus
19	concave	Extrasinus	Extrasinus
20	convex	Intrasinus	Intrasinus
21	convex	Extrasinus	Extrasinus
22	convex	Extrasinus	Extrasinus
23	convex	Extrasinus	Extrasinus
24	convex	Intrasinus	Extrasinus
25	convex	Extrasinus	Extrasinus
26	convex	Intrasinus	Intrasinus
27	concave	Extrasinus	Extrasinus
28	convex	Extrasinus	Extrasinus
29	concave	Extrasinus	Extrasinus
30	concave	Intrasinus	Intrasinus
31	concave	Extrasinus	Extrasinus
32	concave	Extrasinus	Extrasinus
33	concave	Extrasinus	Extrasinus

34	convex	Extrasinus	Extrasinus
35	convex	Intrasinus	Intrasinus
36	concave	Extrasinus	Extrasinus
37	concave	Extrasinus	Extrasinus
38	convex	Intrasinus	Intrasinus
39	convex	Intrasinus	Intrasinus
40	concave	Extrasinus	Extrasinus
41	Convex	Intrasinus	Intrasinus
42	Concave	Extrasinus	Extrasinus
43	Convex	Extrasinus	Extrasinus
44	Convex	Intrasinus	Intrasinus
45	Convex	Extrasinus	Extrasinus
46	Convex	Intrasinus	Intrasinus
47	convex	Extrasinus	Extrasinus
48	Convex	Intrasinus	Intrasinus
49	Convex	Intrasinus	Intrasinus
50	Convex	Intrasinus	Intrasinus
51	Concave	Extrasinus	Extrasinus
52	Concave	Intrasinus	Intrasinus
53	Concave	Intrasinus	Extrasinus
54	Convex	Intrasinus	Intrasinus
55	Concave	Extrasinus	Extrasinus
56	Concave	Extrasinus	Extrasinus
57	Concave	Extrasinus	Extrasinus
58	Convex	Extrasinus	Extrasinus
59	Concave	Extrasinus	Extrasinus
60	Convex	Intrasinus	Intrasinus
61	Convex	Intrasinus	Intrasinus
62	Concave	Extrasinus	Extrasinus
63	convex	Extrasinus	Extrasinus
64	convex	Intrasinus	Intrasinus
65	concave	Extrasinus	Extrasinus
66	convex	Intrasinus	Intrasinus
67	concave	Extrasinus	Intrasinus
68	convex	Intrasinus	Intrasinus
69	convex	Intrasinus	Intrasinus
70	convex	Intrasinus	Intrasinus
71	convex	Extrasinus	Extrasinus
72	concave	Extrasinus	Extrasinus
73	concave	Extrasinus	Extrasinus
74	convex	Intrasinus	Intrasinus
75	convex	Intrasinus	Intrasinus

76	concave	Extrasinus	Extrasinus
77	concave	Extrasinus	Extrasinus
78	convex	Intrasinus	Intrasinus
79	concave	Extrasinus	Extrasinus
80	convex	Intrasinus	Intrasinus
81	concave	Extrasinus	Extrasinus
82	convex	intrasinus	intrasinus
83	convex	Extrasinus	Extrasinus
84	convex	Extrasinus	Extrasinus
85	convex	Extrasinus	Extrasinus
86	convex	Intrasinus	Intrasinus
87	convex	Extrasinus	Extrasinus
88	convex	Intrasinus	Intrasinus
89	concave	Extrasinus	Extrasinus
90	convex	Extrasinus	Extrasinus
91	concave	Extrasinus	Extrasinus
92	concave	Intrasinus	Intrasinus
93	concave	Extrasinus	Extrasinus
94	concave	Extrasinus	Extrasinus
95	concave	Extrasinus	Extrasinus
96	convex	Extrasinus	Extrasinus
97	convex	intrasinus	intrasinus
98	concave	Extrasinus	Extrasinus
99	concave	Extrasinus	Extrasinus
100	convex	Intrasinus	Intrasinus
101	convex	Intrasinus	Intrasinus
102	concave	Extrasinus	Extrasinus
103	Convex	Intrasinus	Intrasinus
104	Concave	Extrasinus	Extrasinus
105	Convex	Extrasinus	Extrasinus
106	Convex	Intrasinus	Intrasinus
107	Convex	Extrasinus	Extrasinus
108	Convex	Intrasi nus	Intrasi nus
109	convex	Extrasinus	Extrasinus
110	Convex	Intrasinus	Intrasinus
111	Convex	Intrasinus	Intrasinus
112	Convex	Intrasinus	Intrasinus
113	Concave	Extrasinus	Extrasinus
114	Concave	Intrasinus	Intrasinus
115	Concave	Intrasinus	Intrasinus
116	Convex	Intrasinus	Intrasinus
117	Concave	Extrasinus	Extrasinus

118	Concave	Extrasinus	Extrasinus
119	Concave	Extrasinus	Extrasinus
120	Convex	Extrasinus	Extrasinus
121	Concave	Extrasinus	Extrasinus
122	Convex	Intrasinus	Intrasinus
123	Convex	Intrasinus	Intrasinus
124	Concave	Extrasinus	Extrasinus
125	convex	Extrasinus	Extrasinus
126	convex	Intrasinus	Intrasinus
127	concave	Extrasinus	Extrasinus
128	convex	Intrasinus	Intrasinus
129	concave	Extrasinus	Extrasinus
130	convex	Intrasinus	Intrasinus
131	convex	Intrasinus	Intrasinus
132	convex	Intrasinus	Intrasinus
133	convex	extrasinus	extrasinus
134	concave	Extrasinus	Extrasinus
135	concave	Extrasinus	Extrasinus
136	convex	Intrasinus	Intrasinus
137	convex	Intrasinus	Intrasinus
138	concave	Extrasinus	Extrasinus
139	concave	Extrasinus	Extrasinus
140	convex	Intrasinus	Intrasinus

LATERAL WALL (140)	Examiner 1		Examiner 2	
	Intrasinus	Extrasinus	Intrasinus	Extrasinus
<b>CONVEX (82)</b>	56	26	51	31
<b>CONCAVE (58)</b>	6	52	7	51