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By Gurumoorthy Kaarthikeyan

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Epidemiological study comparing CBCT measurements of Pterygoid region for the placement of pterygoid implants in south Indian population

Siddharth Narayan, Kaarthikeyan G., Gurumoorthy Kaarthikeyan

Department of Periodontics, Saveetha Dental College and Hospitals, Saveetha Institute of medical and technical sciences, Chennai, Tamil Nadu, India

Corresponding author:

Gurumoorthy Kaarthikeyan

Email - drkrthik79@yahoo.co.in

ABSTRACT

Background. Pterygoid implants are a means of rehabilitating posterior atrophic maxilla in cases where conventional implants are not feasible or require multiple surgical appointments but there is no standardized protocol for their placement due extensive heterogeneity in terms of ethnic origin and anatomic variations among different populations.

Objective. The main objective of the current study was to determine the available bone and its angulation for the placement of pterygoid implant in the pterygomaxillary area, along with the bone density for the same in south Indian population using modified protocol for placement of Pterygoid Implants.

Methodology. A total of 200 patients and their radiographic examination were examined in a prospective multicenter study from a university along with adjacent clinics for patients requiring prosthetic rehabilitation in the form of implants in the posterior atrophic maxilla between January 2021 till December 2021. Two operators used 3D Carestream light image viewer to assess anatomy and record two dimensional measurement required for placement of Pterygoid implants in terms of Measurements of Implant length, diameter, angulation of placement (ref from Frankforts plane) and bone density at the pterygoid area as well as tuberosity.

Results. Among a total of two hundred CBCT assessed, twenty subjects were not eligible for the placement of pterygoid implants while the remaining 180 included patients were eligible based on CBCT measurement. The analysis showed that in 10 % of cases, the virtual implant of 18mm length could be placed , whereas in 38% of cases (76 cases) - the virtual implant length of 15mm and in the remaining 52 % (84 cases) of cases, virtual implants of thirteen millimeter could be placed. All implants appeared to be covered by bone in two-dimensions. The mean implant angulation was 75.22 ± 6.92 degrees as compared to Frankfort plane in the sagittal view (anteroposterior axis).

Conclusion. An implant of either 13 or 15 mm in length and 4mm in diameter should be used at an angulation of approximately 75.22 ± 6.92 degrees would be effective in placement of pterygoid implants in south Indian population.

Keywords: Pterygoid bone, Pterygoid implants, Pterygomaxillary fissure, CBCT

INTRODUCTION

The Maxilla or upper jaw is a porous pneumatic bone filled with the maxillary sinus or Antrum which is pyramidal in shape. Methods to study Anatomy throughout the ages have been either anthropometric measurements or radiographic measurements. Both these methods Anthropometry as well as radiographic evaluation have been associated with some amount of error in terms of accuracy. In case of posterior atrophic maxilla prosthetic rehabilitation can be complicated due to the proximity to maxillary sinus, extent of porosity, natural quality of bone and rate of resorption of alveolar ridge [1,2]. Implants are the most commonly employed methods of prosthetic rehabilitation however, clinical implant placement in relation to the same may be complicated [3]. Clinicians have tried to address these complications by suggesting the use of different surgical techniques for placement of implants such as the use of short implants or sinus lift procedures [4]. The deficient alveolar ridge in posterior segment is handled alternatively by engaging the bone in pterygoid region or zygomatic region; however the placement of implants in such sites requires extensive knowledge of bone anatomy and proximity to vital structures. The first procedure to place the pterygoid implants was given by Tulasne and Tessier in the pterygoid region avoiding grafting [5]. The successful placement of implants required the cortical support provided from the floor of the maxillary sinus along with the lateral wall of the nose. Improper placement of the pterygoid implants can often result in damage to the palatine artery or impingement over the lateral pterygoid plate causing trismus (muscles of mastication).

There is an improvement in the management of tissues with the placement of pterygoid implants, using the remaining available bone in the posterior region of maxilla. The success rate of pterygoid implants are high since the highly dense pterygoid bone is engaged by these implants instead of the porous bone by conventional implants in posterior segment of maxillary arch [6]. All dental clinicians must assess and implement their own protocol for placement of pterygoid implants which may vary based on ethnicity, population and morphology as compared to a two stage procedure including augmenta-

tion of surgical site followed by placement of conventional implants. The correct placement of pterygoid implant should be carried out based on some clinical and radiographic guidelines to avoid complications. Some authors like Bidra et al., suggest the implant inclination angle should be around 45.8 degrees whereas other authors recommend a 74 degree angulation to Frankfort plane [7,8]. Considering the lacunae of research the authors thought it was appropriate to define the ideal clinical implications to be followed for the placement of such implants to improve prosthetic rehabilitation. Thus the objective of the current study was to determine the available bone and its angulation for the placement of pterygoid implant in the pterygomaxillary area, along with the bone density for the same in south Indian population using modified protocol for placement of Pterygoid Implants.

MATERIALS AND METHODS

This study was performed as a multicenter prospective clinical trial involving a university along with feeder clinics attached to the same which utilized university cone beam computed tomography (CBCT) facility for the placement of implants. After obtaining appropriate approval from the university Ethical committee (IHEC/SDC/PERIO-1802/ 20/26) and informed consent from all the patients. A total of 200 patients and their radiographic examination were included for patients who required prosthetic rehabilitation in the form of implants in the posterior atrophic maxilla.

In terms of ethnicity, all of the CBCTs were acquired from a south Indian adult population with an atrophic posterior maxillary between the age group of 28 to 66 years comprising 112 males and 88 females. All included patients had edentulism in relation to the maxillary molars with residual alveolar ridge height was < 8 mm (height measured from the crest to the floor of maxillary sinus). The exclusion criteria was (i) unclear or incomplete images (ii) the presence of maxillary molars (iii) > 8 mm of alveolar ridge height in maxillary posterior region (iv) systemic conditions affecting the underlying bone, pregnant women and lactating mother. It was made sure that the virtual implants were 360 ^{degrees} covered by bone, as seen two-dimensionally.

Study design

A CBCT scanner (CS 9600 Care stream flat panel detector) was used in all cases. The exposure volume set at 100 mm diameter and 102 mm height for CBCT analysis. The exposure settings of CBCT was kept at 122 kV and 6.4 mA and an exposure of 798 mGy/cm^2 for fifteen seconds as recommended by mmanufacturer. The Frankfort plane was used for analysis due to the incline produced by edentulism in the maxillary molar region. The axial images DICOM files of the CBCT were imported and analyzed using the 3D Image Light Carestream software.

Radiographic Measurements

The radiological measurements were performed by two independent investigators under the guidance of a senior periodontist. Two dimensional placement of 4mm diameter pterygoid implants of 13, 15 or 18 millimeters in length were virtually placed in the pterygomaxillary area with a safe distance of two millimeter between the implant and the vital structures like artery and palatine nerve. It was made sure that these virtual implants were covered by bone all around. There was bicortical stabilization of these implants with the crestal level engagement on the mesial side virtually and the apical level engagement between the pterygoid apophysis and the posterior sinus wall. The virtual placement of the pterygoid implant was such that the implant inclination was slightly towards the palatine bone in accordance with the cortical area of the palatine bone. The perfect three dimensional positioning of the pterygoid implant was guided by the posterior sinus wall, palatine bone and the pterygoid apophysis as suggested by Rodriguez at al [9].

The parameters assessed included measurements made from (1) the angulation of implant to Frankfort plane in anteroposterior axis on panoramic view; (2) the implant angulation relative to Frankfort plane on the buccal palatal axis (3) the distance from the maxillary tuberosity alveolar ridge to the most apical point of the pterygoid apophysis (4) bone density in the pterygo-maxillary fissure (5) density of the bone was recorded in grey scale.

The study has been conducted in accordance with the STROBE guidelines.

Statistical analysis

All two dimensional measurements were recorded by two independent operators (SN and SS) under the guidance of (KG) with a kappa coefficient of at least 90% to reduce bias. All data procured in this study was assessed as mean ± standard deviation where SPSS version 23 (IBM Corp., Armonk, NY, USA) was utilized for assessment. Chi square test was employed to assess the relation between age, gender, bone density and implant dimensions placement while ANOVA was performed to assess intra group and intergroup significance. Statistical significance was found between bone density and angulation of implant as compared to dimensions of implant which can be placed (figure 2,3). The level of significance was kept at p value < 0.05.

RESULTS

A total of two hundred CBCTs were assessed, twenty patients were not eligible for the placement of pterygoid implants while the remaining 180 included patients were eligible based on measurements. The analysis showed that in 10% of cases, the virtual implant of 18 mm length could be placed, whereas in 38% of cases (76 cases) - the virtual implant length of 15 mm and in the remaining 52 % (84 cases) of cases, virtual implants of thirteen millimeter could be placed. All implants appeared to be covered by bone in two-dimensions. The mean implant angulation was 75.22 ± 6.92 degrees as compared to Frankfort plane in the sagittal view (anteroposterior axis) as shown in figure 3. The average bone length following the long axis of the implant was 16.28 ± 1.87 mm as shown in table 1.

The mean bone density as measured in grey scale in the tuberosity area was 1352 ± 135.29 while the mean bone density in the pterygoid region was 1708 ± 163.08 grey scale value with a 95% confidence interval as shown in figure 2. The difference in bone density between the two areas (tuberosity and pterygoid) was on an average of 356 grey scale values. In terms of percentage, the density in the pterygoid area was 126.33 % higher than in the alveolar ridge region.

DISCUSSION

The rationale for the placement of pterygoid implants was based on the need for fewer appointments required for treatment as compared to two stage treatment comprising a primary appointment for ridge augmentation or sinus lift procedures followed by a subsequent appointment for the placement of conventional implants [5]. Though these implants require an additional amount of skill for placement to avoid injury to anatomical vital structures they also have the benefit of obtaining support from basal bone which does not solely rely on alveolar crest. As compared to conventional implants pterygoid implants have limited evidence in literature which seem to suggest similar success rates and long term clinical outcomes [7,10].

The most common shortcomings while placing pterygoid implants include severe bleeding, difficult prosthetic rehabilitation due to angulation, excessive soft tissue inflammation. Alteration in soft tissue thickness at the tuberosity during implant placement is recommended by some authors to prevent future pocket depth after placement [9]. Anatomical and morphological variations are routinely present among different ethnic origins and such as size and shape of upper and lower jaw, position of vital structures especially structures like position greater palatine artery among different populations as close as the south Asian sub-continent itself had vast variations [11,12]. Though such differences are considered trivial they have a much deeper impact of drill angulation to facilitate ideal prosthetic rehabilitation along with an adjacent anterior conventional implant without incident. There are few cases in literature where complications were seen as a direct result of placement of implants with postoperative patient complaints of pain on the side of surgical placement and limited mandibular opening. Clinical and radiographic examination revealed displacement of Implant into pterygoid fossa with close proximity to vital anatomical structures namely carotid artery with a high potentiation of migration [13].

The present study demonstrated that the south Indian population had a mean bone density of about 1352 ± 135.29 grey scale value while the mean bone density in the pterygoid region was 1708 ±

163.08 grey scale value compared to the studies done on a caucasian population with values of ranging from 285.8 to 329.1 DV at the tuberosity and 602.9 to 661.2 DV at the pterygoid [9]. The clinical significance of bone density could be associated with potential fracture of the maxillary tuberosity causing deafness due to the collapsing of eustachian tube opening. The collapsing occurs due to the disruption of the hamular notch and tensor veli palatini which was seen in one of the cases discussed by Cattlin in 1858 in Colemans extraction of teeth [14]. Our findings in regards to the angulation of placement seems to have changed minimally with a value of 75.22 ± 6.92 degrees as compared to 74.19 degrees seen in previous studies. Studies performed in an Indian population to assess pterygomaxillary region revealed that the mean volume of pterygomaxillary joint in dentate patients was significantly higher (288.4± 194.2 mm^3) than that seen among edentulous patients with a mean of 256.6± 172.4 mm^3 [15].

In order to freely utilize the modified protocol suggested by Rodriguez et al for the placement of pterygoid implants it is recommended to use limiting surgical stents instead of CBCT measurements alone. All dental prosthesis ultimately aspire to closely imitate the biomechanics of natural teeth as possible without bearing excessive functional occlusal load. The pterygoid implant angulation found in the modified pterygoid placement protocol was found to follow the axis of the second molar with a more physiological placement and a vertical angulation.

Another salient finding of this study was that most cases could utilize with 13 mm implants (42%) or 15 mm implants (38%) despite most studies recommending the use of <15 mm in length in this area [16]. The current evidence shows that the survival rate of longer implants (15-18mm) is higher (94%) compared to shorter implants with survival rate of 88%. The reason for better survival rate in longer implants could be due to the engagement in the dense bone area of the pterygomaxillary zone. This leads to the better primary stability, thereby yielding a better survival rate [17]. According to Jaffin and Berman, the implant failure was higher when placed in bone quality type IV (approximately 35%), whereas the failure for implants placed in bone of type I, II, and III quality was around 3% only [1]. There is sufficient evidence in literature to suggest that bone density affects the primary

implant stability and in turn affects the osseointegration in the posterior atrophic maxilla. Bone density obtained preoperatively by CBCT examination is however often in grey scale despite Hounsfield units being represented as one of the more standardized scales for CT scans, there despite no active calibrations were conducted [18].

The present study analyzed two dimensional measurements using two independent operators to record all measurement, however a two dimensional measurement will always be dimensionally inaccurate compared to a three dimensional measurement. There is no standardized unit for bone density, the present study utilized grey scale value as while other studies which used hounsfield units and DV which may lead to different values.

CONCLUSION

It could thus be summarized that for the effective placement of pterygoid implants of either 13 or 15 mm in length should be used at an angulation of approximately 75.22 ± 6.92 degrees would be effective in Chennai based population.

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Table 1- Tabular illustration of demographic data of individuals included in the study in terms of age, gender, mean bone density at pterygoid, mean bone density at tuberosity, mean column of length available along long axis of implant and mean implant angulation.

Feature	Value
Total Number of Individuals (n)	200
Mean Age (years)	40.92 ± 10.99
Gender	112 Males 88 Females
Mean Bone Density at Pterygoid (grey scale value)	1708 ± 163.08
Mean Bone Density at Tuberosity (grey scale value)	1352 ± 135.29
Mean Column length following long axis of Implant	15.28 ± 1.87 mm
Mean Implant angulation as compared to Frankfort plane (degrees)	75.22 ± 6.92

Legend

Figure 1-Schematic illustration where Cone beam computed tomographic image measurements obtained from 3D Carestream light image viewer were superimposed to match Anatomy of a skull with mean column of length of 15.1mm for the placement of an implant of dimensions 13x4 mm at an angulation of 74 degrees.

Figure 2- Graphical illustration between the association of the bone density at the pterygoid area Dimensions of Implant which can be placed using modified pterygoid implant placement protocol; X axis depicts the bone density in (greyscale values); Y axis depicts the number of individuals (n); Legend depicts the dimensions of implants which can be placed. Chi square was used to assess association between Implant dimensions and bone density at the pterygoid area which was found to be statistically significant, where ($p < 0.05$) was considered to be statistically significant.

Figure 3- Graphical illustration between the association of the angle of pterygoid implant placement using modified implant placement protocol and Dimensions of Implant which can be placed; X axis depicts the dimensions of implants which can be placed (mm^2); Y axis depicts the angulation of Implants (degrees); Chi square was used to assess association between Implant dimensions and implant angulation which was found to be statistically significant, where ($p < 0.05$) was considered to be statistically significant.

Figure 4- Pterygoid Implant angulation

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Conflict of interests

The authors declare that there is no conflict of interest in relation to the present research paper.

Ethical Committee Approval No.

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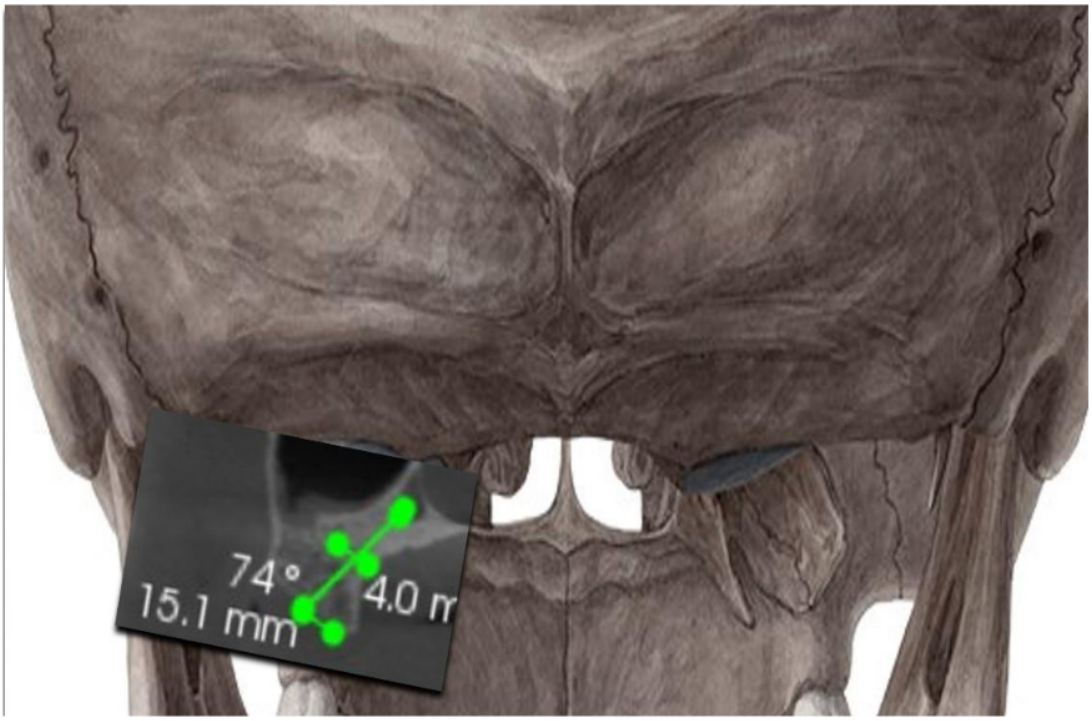
Author contriution:

1. Dr.Sidharth Narayan- Selection of cases, CBCT analysis and data recording, result analysis
2. Dr. Subasree soundararajan- CBCT analysis , manuscript writing
3. Prof.Gurumoorthy Kaarthikeyan- conceptualisation, literature review, supervising the study , CBCT analysis, statsistics, final manuscript review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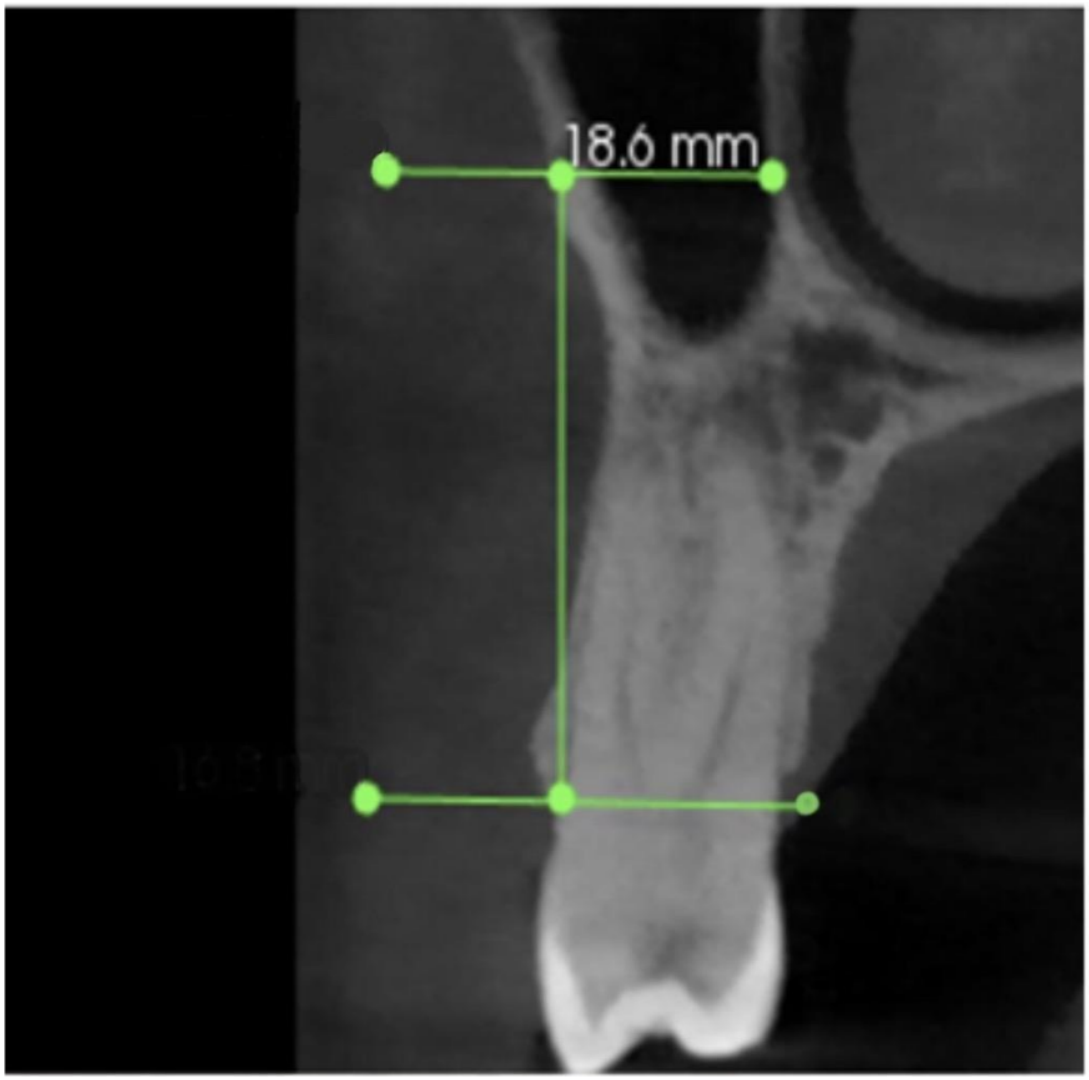
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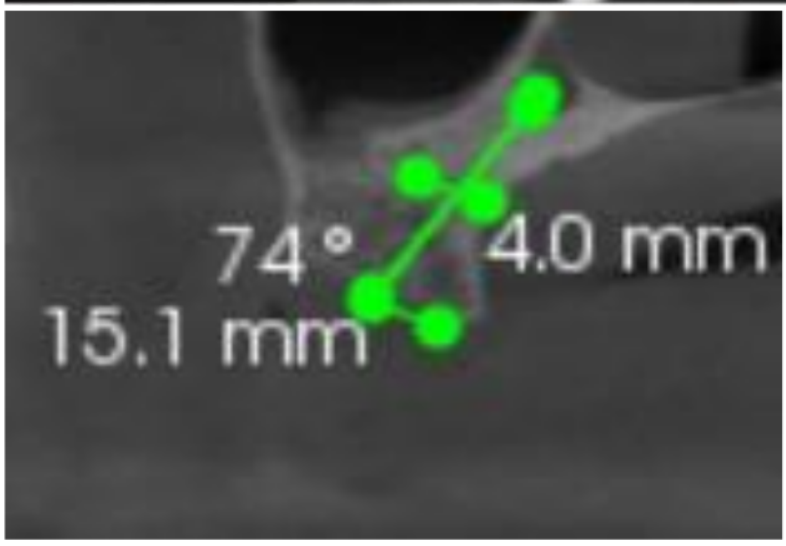
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