Original Article

A cone-beam computed tomography evaluation of bone density for insertion of pterygoid implants in dentulous and edentulous patients

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Abstract

Objectives: The bone quantity and quality determine the prosthetic success outcome. This research was performed to evaluate the bone density for insertion of pterygoid implants in edentulous and dentulous participants with cone-beam computed tomography (CBCT). **Materials and Methods:** CBCT evaluation was done for 66 dentate and edentulous patients for pterygoid implants at the pterygomaxillary region. The calculation of joint width, height, and volume of bone was done. Density of the bone was evaluated at the superior and inferior aspects of the pterygomaxillary column. **Results:** It was observed that average pterygomaxillary joint height for dentulous (dentate) was −12.7 ± 7.2 mm, edentulous −12.4 ± 7.1 mm, the average pterygomaxillary joint width for dentulous was 8.15 ± 7.3 mm, and 8.13 ± 6.2 mm for edentulous. The average pterygomaxillary joint volume in dentulous participants was 279.4 ± 189.2 mm^3 and for edentulous was 254.5 ± 176.4 mm^3. There was expressively greater density of the bone in dentulous participants over edentulous participants ($P < 0.05$). **Conclusion:** There was better bone density found in dentate participants in comparison to edentulous participants. CBCT is a recent investigative device which measures pterygoid area efficiently. Pterygoid implants may be deliberated as an alternative method for resorbed (atrophic) maxilla.

Keywords: *Atrophic, Cone-beam computed tomography, Implants, Maxilla, Pterygoid*

Introduction

*D*entition is essential for esthetics appearance and eating purpose. Teeth loss can result into deprived outline and reduced masticatory function. Lost teeth replacement with removable, complete, or fixed denture resolves the need [1], whereas dentist and patient can choose the type of prosthesis. Alveolar bone has a negative effect with missing anterior teeth [2]. In long-standing edentulism, there is a chance of loss of bone height. In edentulous area, pneumatization of maxillary sinus is fairly noticeable [3].

Dental implants are recommended for the replacement of lost teeth. The bone quantity and quality determine the outcome of implant prosthesis. Placement of dental implant in the maxillary posterior area with atrophic/resorbed/reduced vertical height of maxilla deliberated as challenging to dentists even though with higher dental implants success rate [3]. Type IV bone and inadequate bony measurements are reflected to be restraining elements. Indirect or direct sinus lift can be advised in cases of reduced vertical height; but it cannot be advised in all conditions [4]. Alternatively, short dental implants and tuberosity implants can be considered in such

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cases [5]. Pterygoid implants are alternative for tuberosity and conventional dental implants for atrophic maxilla cases. They are technique sensitive procedure. Dentist should be conscious about the anatomical standards such as maxillary artery and pterygomaxillary fossa during pterygoid implant placement. Cautious valuation of greater palatine nerve is important to avoid iatrogenic injuries [6].

Assessment with radiograph of pterygomaxillary area delivers beneficial evidence before planning for implants in this area. Panoramic radiographs which are of two-dimensional radiographs cannot provide required information. Hence, the use of three dimension images with cone-beam computed tomography (CBCT) may be helpful in pterygoid implant placement [7]. The present research was done to evaluate bone density and pterygomaxillary joint values in dentate and edentulous patients for pterygoid implant placement with CBCT.

MATERIALS AND METHODS

The present prospective research was done from March 2017 to December 2019 on 66 participants (male and female) in the department of prosthodontics for pterygoid implants placement after attaining No objection certificate authorization from the Institutional Ethical Committee of Medical sciences (IMS) and Sum Hospital Siksha 'O' Anusandhan (Deemed to be University) Bhubaneswar, Orissa, India, dated: 08-01-2017, with IRB Ref No/DMR/IMS-SH/SOA/180024. Participants chosen for the research were well intimated in local understandable language, and informed consent was attained from all study participants. The inclusion measures were dentulous or edentulous participants with age varies from 18 to 58 years and participants with poor bone quality and quantity in maxillary posterior and tuberosity area with a residual bony ridge (atrophic) of lesser than 7 mm among the sinus floor and alveolar crest (atrophic maxilla). Insufficient bone height, width indicated poor quality and less density indicated poor quantity of the bone.

History of hypertension, diabetes, nondiagnostic CBCT images, traumatic injury to the region, local bony pathology, and implant positioned in the maxillary tuberosity were excluded from the study.

The demographic profile of all participants was recorded. The measurement was attained with a 99% confidence level, an accurateness of 1% and at discrepancy of 3.62 and 7.28. It was found that the 66 sample size for the bone density variable with a margin of error of <10%, for hemimaxillas. The following formula included for sample size evaluation:

$$n = \frac{Z_{\alpha/2}^2 \, pq}{d^2}$$, where P is implant persistence, $q = 1 - p$, d is the margin of error, $Z_{\alpha/2}$ is the ordinate of standard normal distribution at $\alpha\%$ level of inference. A sample size of 66 with 40 dentulous and 26 edentulous participants were included.

All participants underwent for oral examination by trained dental surgeon. Assessment of panoramic radiographs was done before the placement of implant to evaluate the volume of residual bone at the pterygomaxillary region. Participants were exposed to CBCT evaluation (Carestream [Kodak] CBCT Dental Machine, New Delhi, India) of the pterygomaxillary region during pterygoid implant placement.

Before radiographic evaluation, all participants were instructed to remove any metallic objects, ornaments, and artificial prostheses in the head and neck area. Patient's frank fort horizontal plane was set parallel to the floor and was directed to bite on bite block. Sectional CBCT was obtained by altering variables at 80 kVp, 10 mA, and exposure time of 15 s. Image resolution was kept at 0.3 μm. After gaining the primary image, multiplanar reorganization was obtained. Coronal, axial, and sagittal planes were attained for evaluation.

AMIRA® 6.0 software (AMIRA, Mercury Computer Systems, Berlin, Germany) was included to evaluate degree and to produce three-dimensional images of the pterygomaxillary area. Two independent investigators accomplished all radiographic calculations in the presence of observation by trained oral surgeon.

Joint width: This aspect was designated as the joint width of the maxillary tuberosity and the pterygoid process in millimeters (mm), and the pyramidal process if present, calculated on the first axial plane where a full joint contact was detected. Joint height: This component was designated as the calculation in millimeters (mm) among the most caudal and most cranial points of the pterygomaxillary joint, which was included the pterygomaxillary column. Bone volume: this element was pronounced as the total volume of bone in cubic millimeters (mm³). The area of the study was demarcated by the following borders: The maxillary sinus, the posterior wall, the pterygoid, the inferior limit of the pterygomaxillary fossa, the separation of the tuberosity, and pterygoid process and scaphoid process. For bone density, nine aspects were assessed: 3 points at the upper aspect, 3 points at the lower aspect of the pterygomaxillary column, and 3 in a medium zone equidistant from the two previously specified points. These areas were calculated at the joint between the maxillae and the pterygoid/pyramidal process, the anterior limit (posterior sinus wall), and the posterior limit (scaphoid or pterygoid fossae). Using CBCT, density of the bone was calibrated in gray scale density (GSD) values. Gray scale values from CBCT can be included to evaluate quality of bone, conferring to an earlier research. The patient is considered as dentate/dentulous if the second or third upper molars were present. If none of these molars was present, the patient was considered edentulous [8].

Pterygoid implants of 13, 15, or 16 mm in length and 3.5 mm in diameter were positioned in the pterygomaxillary region through the bony corridor, preserving a safety space of 2 mm among the palatine nerve and artery and the implant. All implants were positioned so that bone covered three dimensionally. The implant platform was positioned at a crestal level on the mesial side, and the implant apex was placed between the posterior sinus wall and the pterygoid apophysis [Figures 1 and 2]. Measurement was done at the maximum height and width at pterygoid processes.
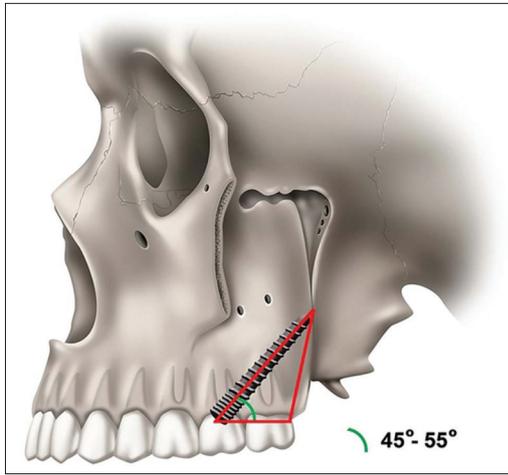
Figure 1: Pterygoid process for pterygoid implant placement and measurement
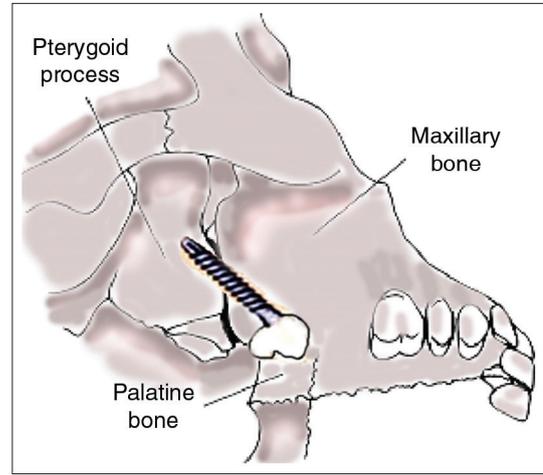

Figure 2: Pterygoid process for pterygoid implant placement

Density of the bone was calculated at two points each at the upper aspect, medium, and on the lower aspect of the pterygomaxillary column in GSD and GSD. Total volume of bone was calculated as, length × width × height × 1/2 in mm³. Since choosing different points could lead to varying result; hence, measurement was done at the upper aspect, medium, and on the lower aspect of the pterygomaxillary column where dental implants were to be inserted.

CBCT image evaluation was accomplished by two trained independent radiologists by Newton new technology software. Average value was considered as final measurement.

Statistical evaluation

Obtained data tabulated and statistically analyzed with the SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Joint width, height, and volume of the bone were conveyed as an average ± standard deviation (SD). Density of the bone was stated in GSD. Kolmogorov–Smirnov test was used for associating the parameters. Implication was considered below 0.05.

RESULTS

Table 1 indicates that there were 40 (60.6%) dentulous and 26 (39.4%) were completely edentulous participants. In dentulous (Group I) participants, 21 (52.5%) were male and 19 (47.5%) were female, and in edentulous (Group II) participants, 14 (53.8%) were male and 12 (46.1%) were female. The mean age in Group I was 46.2 years and in Group II was 44.1 years.

Table 2 indicates that the mean ± SD height of pterygomaxillary joint in dentulous participants was 12.7 ± 7.2 mm and in edentulous participants was 12.4 ± 7.1 mm. The mean width of pterygomaxillary joint in dentulous participants was 8.15 ± 7.3 mm and in edentulous patients was 8.13 ± 6.2 mm. The mean volume of pterygomaxillary joint in dentulous participants was 279.4 ± 189.2 mm³, and in edentulous, it was 254.5 ± 176.4 mm³. There were higher pterygomaxillary joint values for width, height, and volume in dentulous as compared to edentulous patients. There was substantial variance in volume and width of pterygomaxillary joint in dentulous and edentulous participants ($P < 0.05$).

Table 1: Patients' distribution in percentage (%)

Gender	Group I: Dentulous (*n*=40; 60.6%)	Group II: Edentulous (*n*=26; 39.4%)
Male	21 (52.5)	14 (53.8)
Female	19 (47.5)	12 (46.1)
Mean age (years)	46.2	44.1

Table 2: Dimension of parameters in dentulous and edentulous participants

Parameters (mean)	Mean±SD		*P*
	Dentulous (*n*=40)	Edentulous (*n*=26)	
Pterygomaxillary joint height (mm)	12.7±7.2	12.4±7.1	0.16
Pterygomaxillary joint width (mm)	8.15±7.3	8.13±6.2	0.01*
Pterygomaxillary joint volume (mm³)	279.4±189.2	254.5±176.4	0.001*

*$P>0.05$ significant, statistics method used: Kolmogorov–Smirnov test. SD: Standard deviation. 0.01: Significant, 0.001: Highly significant

Table 3 indicates that in dentulous participants, at upper aspect, average gray scale bone density (GSD) at the anterior limit of the pterygoid process was 458.4 and in edentulous participants was 44.2, at pterygomaxillary joint was 562.2 in dentulous participants and 522.2 in edentulous participants, at posterior border in dentulous participants was 703.2 and in edentulous participants was 665.6. At middle section, mean bone density (GSD) at the anterior limit of the pterygoid process of dentulous subjects was 485.3 and in edentulous participants was 404.8, at pterygomaxillary joint was 625.8 in dentulous participants and 612.2 in edentulous participants, at posterior limit in dentulous participants was 720.4 and in edentulous participants was 649.2. At lower aspect, average bone density of the bone (GSD) at anterior limit of the pterygoid process in dentulous participants was 379.4 and in edentulous participants was 352.2, at pterygomaxillary joint was 591.2 dentulous participants and 538.8 in edentulous participants, at posterior limit in dentulous participants was 667.2 and in edentulous participants was 632.4. There were superior bone density

Table 3: Dimension of bone densities in dentulous and edentulous participants

Region	Mean (mm)±SD		P
	Dentulous (*n*=40)	Edentulous (*n*=26)	
Superior segment (GSD)			
AL	458.4±119.6	441.2±113.2	0.05*
PMJ	562.2±130.7	522.2±141.4	0.01*
PL	703.2±105.1	665.6±104.2	0.00*
Middle segment (GSD)			
AL	485.3±94.2	404.8±109.2	0.03
PMJ	625.8±87.6	612.2±96.6	0.001*
PL	720.4±81.4	649.2±84.4	0.01*
Inferior segment (GSD)			
AL	379.4±86.4	352.2±96.6	0.05*
PMJ	591.2±98.2	538.8±93.4	0.03
PL	667.2±94.6	632.4±97.2	0.05*

*P>0.05 significant. GSD: Gray scale density, AL: Anterior limit, PMJ: Pterygomaxillary joint, PL: Posterior limit, Test used: Kolmogorov–Smirnov test, SD: Standard deviation

values (DVs) for dentate compared to edentulous cases. The variance was important ($P < 0.05$).

DISCUSSION

Placement of dental implants in the maxillary posterior region with atrophic maxilla is one of the greatest challenging conditions due to its anatomy, existence of the maxillary sinus, inadequate bone volume, reduced quality of bone, and poor access to area [9,10]. According to Lekholm and Zarb classification system, the posterior maxillary area is considered by insufficient residual bone height due to maxillary sinus extension and/or alveolar bone resorption and reduced bone density (Type III or IV). To overcome these problems, sinus lift procedures, guided bone regeneration grafting, Zygomatic implants, and short and tilted implants were suggested but were not advised due to risk of sinus membrane perforation, and chances of graft rejection and these surgical methods need longer healing time. The alveolus in the maxillary posterior area has greater fatty marrow area and cortical bone covering [11]. Moreover, the use of lengthier posterior cantilevers may result into fracture of prosthesis and failure of osseointegration. Alternatively, maxillary tuberosity and distal to maxillary sinus can be suggested for implant placement. Pterygoid implants may be suggested in participants with atrophic/reduced bone measurement in maxillary posterior area. Pterygomaxillary region implant placement shows osseointegration and offers retention and stability. Tulasne in 1992 introduced the concept of ptrygomaxillary implant (pterygoid implants/tuberosity implants). Pterygoid implants can be suggested for all age groups and systemic circumstances unless there are true surgical contraindications. The dimension of pterygoid implants varies from 15 mm to 20 mm. Several researchers have suggested the placement of the pterygoid implant at an angulation of 45° relatives to the Frankfort horizontal plane. Pterygoid implants are generally inserted through the pterygoid process into the pterygoid fossa with an inclination of the long axis of the implant and slightly toward the palatine bone [9,12]. In contrast, tuberosity implants are placed at the most distal portion of the

maxillary alveolar process (tuberosity region), which is mainly composed of type 3 or 4 cancellous bone and rarely with an angulation above 10° [10]. The pyramidal process of palatine and pterygoid process of the sphenoid is mainly consists of dense cortical bone, which is deliberated during pterygoid implant insertion. The pterygoid fossa is bordered by median and lateral pterygoid plates [9,12].

The greater advantage of pterygoid implant is, it eliminates the need of sinus lift surgeries or bone grafts and thus shortens the treatment time. While inserting a pterygoid implant, it is important to consider the proximity of greater palatine canal and nerve [8]. However, the disadvantages being, severe bleeding and prosthetic complications [9]. The outcome of pterygoid implants based on clinical ability and capability of the dentist [13]. Present research employed CBCT in evaluating pterygomaxillary area for bone density in the location of pterygoid implants for dentulous and edentulous participants.

Luis *et al*. suggested the classification of pterygoid anatomic radiographic prediction (PARP) for implantology in the pterygomaxillary region; PARP 1-when there is no sinus invasion and bone in all its route, PARP 2-when there is a sinus invasion but still has >10 mm of the remaining bone, PARP 3-when there is a sinus invasion leaving a bone surface between 5 mm and 9 mm of remaining bone and PARP 4-in cases of a large sinus invasion, leaving only a remaining bone smaller than 5 mm, the possibility of using long pterygoid implants. With the help of PARP, the selection of implant is individualized for each patient. Nag *et al*. from their systemic review established that pterygoid implants have greater accomplishment rates, less bone loss, and good acceptance by patients [12].

We perceived that average width of pterygomaxillary joint and our outcomes is in uniformity with the outcomes attained in study by Chin *et al*. [14] Curi *et al*. [10] assessed 3 years' existence rate of 238 pterygoid implants in 56 participants. They observed that the existence chances of pterygoid implants were 99% and prosthesis persistence rate was 97.7%. Similar to Curi *et al*. [10] study who used only 56 patients, and Salinas-Goodier *et al*. who used only 56 patients, we have also evaluated pterygoid implants on 66 patients [8,10].

Rodríguez *et al*. [9] evaluated of the pterygoid region using 202 CBCT images. Density in the tuberosity region varies from 285.8 to 329.1 DV units and density in the pterygoid plate area from 602.9 to 661.2 DV units. They concluded that the density in the pterygoid area was 139.2% superior to the tuberosity zone. In our study, we observed that average density of the bone at the middle section was greater followed by the upper and lower aspect. Middle section gives anchorage for pterygoid implants. In the present research, values were slightly greater. It was greater in dentulous participants in comparison to edentulous participants. This is due to the fact that dentulous participants have higher muscular strength which develops into a more osseous density.

Balshi *et al*. [11] assessed 1817 implants in 189 patients with completely edentulous maxillae which were placed

into the pterygomaxillary zone, and all participants were rehabilitated with prosthetic appliance. They observed 88.2% of survival rate of implant in edentulous maxillary arches. Valerón and Valerón [15] observed 94.7% success rate with 152 implants inserted in pterygomaxillary pyramidal area. They concluded that pterygoid implants can be efficiently advised alternative to zygomatic and conventional implants.

Bidra and Huynh-Ba [16] from systematic review advocated that pterygoid implants shows greater survival and outcome rate in contrast to conventional one. It was found that the pterygoid technique is expectable and has similar outcome rates on long-term clinical follow-up compared to conventional implants [16]. Rodrı'guez *et al.* concluded from their study that, implant with ≥15 mm had greater success rate and suggested pterygoid implant angulation of around 74° in antero-posterior axis and 81° in buccopalatal axis in relation to the Frankfort horizontal plane [9]. It was observed from many researchers that, pterygomaxillary implant offers bone anchorage in the posterior maxilla and can remove the harmful possessions of cantilever-induced loading forces. It was found that the success rate of pterygomaxillary region implant ranged from 80% to 99% [10].

Salinas-Goodier *et al.* from the retrospective observational study using CBCT evaluated 52 patients for pterygoid implant. Among 52 patients, 28 were female and 24 were male and 31 were dentate and 21 were edentulous patients. Density of bone, height, width, and volume was evaluated in the numerous positions of the maxilla and pterygoid process. They concluded that, in the maxilla, bone density was significantly lower in female participants than in male and greater osseous density observed in dentulous participants in the pterygoid process [8]. Balaji *et al.* from the case report on pterygoid implant at 6 months' follow-up concluded that, pterygomaxillary region gives an excellent posterior bone support without augmenting maxillary sinus [17].

Vrielinck *et al.* evaluated zygoma (18), pterygoid (6), and regular platform (24) implants through 12 edentulous case studies and found survival rates of 92% for the zygoma implants and 93% for platform implants [18]. Ardekian *et al.* concluded from the prospective study that, pterygoid implants have a greater attainment level, with negligible problems and similar bone loss in comparison to conventional implants [19]. Rodrı'guez *et al.* stated that 18 mm length of pterygoid implant is more favorable [20].

In the present study, CBCT was used, and it shows three-dimensional image benefits over two-dimensional radiographs such as orthopantomography. All the CBCT planes can be employed for evaluating implant placement. Presurgical evaluation of pterygomaxillary area with CBCT is efficient in decreasing the problems of improper dental implant placement. Moreover, CBCT decreases patient's exposure expressively in comparison to CT scan [21,22].

The drawback of this research is minimal sample size selected. The angulation of pterygoid implants in the pterygoid region was not evaluated.

Conclusion

Density of the bone was observed to be greater in dentulous in comparison to edentulous participants. CBCT can be used to evaluate the pterygoid region for implant placement. It was observed that, dentate patients had higher bone density and pterygomaxillary joint values compared to edentulous.

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Conflicts of interest

There are no conflicts of interest.

References

1. Jivraj S, Chee W, Corrado P. Treatment planning of the edentulous maxilla. Br Dent J 2006;201:261-79.
2. Tadinada A, Fung K, Thacker S, Mahdian M, Jadhav A, Schincaglia GP. Radiographic evaluation of the maxillary sinus prior to dental implant therapy: A comparison between two-dimensional and three-dimensional radiographic imaging. Imaging Sci Dent 2015;45:169-74.
3. Candel E, Peñarrocha D, Peñarrocha M. Rehabilitation of the atrophic posterior maxilla with pterygoid implants: A review. J Oral Implantol 2012;38:461-6.
4. Apinhasmit W, Methathrathip D, Ploytubtim S, Chompoopong S, Ariyawatkul T, Lertsirithong A. Anatomical study of the maxillary artery at the pterygomaxillary fissure in a Tai population: Its relationship to maxillary osteotomy. J Med Assoc Tai 2004;87:1212-7.
5. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc 2006;72:75-80.
6. Balshi TJ, Wolfinger GJ, Slauch RW, Balshi SF. Brånemark system implant lengths in the pterygomaxillary region: A retrospective comparison. Implant Dent 2013;22:610-2.
7. Graves SL. Te pterygoid plate implant: A solution for restoring the posterior maxilla. Int J Periodontics Restor Dent 1994;14:512-23.
8. Salinas-Goodier C, Rojo R, Murillo-González J, Prados-Frutos JC. Three-dimensional descriptive study of the pterygomaxillary region related to pterygoid implants: A retrospective study. Sci Rep 2019;9:16179.
9. Rodríguez X, Lucas-Taulé E, Elnayef B, Altuna P, Gargallo-Albiol J, Peñarrocha Diago M, et al. Anatomical and radiological approach to pterygoid implants: A cross-sectional study of 202 cone beam computed tomography examinations. Int J Oral Maxillofac Surg 2016;45:636-40.
10. Curi MM, Cardoso CL, Ribeiro Kde C. Retrospective study of pterygoid implants in the atrophic posterior maxilla: Implant and prosthesis survival rates up to 3 years. Int J Oral Maxillofac Implants 2015;30:378-83.
11. Balshi TJ, Wolfinger GJ, Balshi SF 2nd. Analysis of 356 pterygomaxillary implants in edentulous arches for fixed prosthesis anchorage. Int J Oral Maxillofac Implants 1999;14:398-406.
12. Nag PV, Sarika P, Bhagwatkar T, Dhara V. Pterygoid implant: Option for rehabilitation of the atrophic posterior maxilla. Int J Contemp Dent Med Rev 2019;2019:1-5.
13. Lee SP, Paik KS, Kim MK. Anatomical study of the pyramidal process of the palatine bone in relation to implant placement in the posterior maxilla. J Oral Rehabil 2001;28:125-32.
14. Chin YP, Leno MB, Dumrongwongsiri S, Chung KH, Lin HH, Lo LJ. The pterygomaxillary junction: An imaging study for surgical information of LeFort I osteotomy. Sci Rep 2017;7:9953.
15. Valerón JF, Valerón PF. Long-term results in placement of screw-type implants in the pterygomaxillary-pyramidal region. Int J Oral Maxillofac Implants 2007;22:195-200.
16. Bidra AS, Huynh-Ba G. Implants in the pterygoid region: A systematic

review of the literature. Int J Oral Maxillofac Surg 2011;40:773-81.

17. Balaji VR, Lambodharan R, Manikandan D, Deenadayalan S. Pterygoid implant for atrophic posterior maxilla. J Pharm Bioallied Sci 2017;9:S261-3.

18. Vrielinck L, Politis C, Schepers S, Pauwels M, Naert I. Image-based planning and clinical validation of zygoma and pterygoid implant placement in patients with severe bone atrophy using customized drill guides. Preliminary results from a prospective clinical follow-up study. Int J Oral Maxillofac Surg 2003;32:7-14.

19. Ardekian L, Levit L, Ishabaiv R, Levit M. Pterygoid dental implants: An alternative solution for treatment of posterior atrophic maxilla.

Clinical report on a series of 20 patients. World J Oral Maxillofac Surg 2018;1:1-4.

20. Rodrı'guez X, Mendez V, Vela X, Segala M. Modified surgical protocol for placing implants in the pterygomaxillary region: Clinical and radiographic study of 454 implants. Int J Oral Maxillofac Implant 2012;27:1547-53.

21. Khongkhunthian P, Jomjunyong K, Reichart PA. Accuracy of cone beam computed tomography for dental implant treatment planning. CMU J Nat Sci 2017;16:51-62.

22. Alamri HM, Sadrameli M, Alshalhoob MA, Sadrameli M, Alshehri MA. Applications of CBCT in dental practice: A review of the literature. Gen Dent 2012;60:390-400.