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IP Annals of Prosthodontics and Restorative Dentistry

Journal homepage: www.ipinnovative.com

Review Article

Bone mapping as a diagnostic approach in Oral Implantology

Nitin Sharma[1],*, Archana Nagpal[2], Ijaz Ahmad Bhat[2]

[1]*Dept. of Oral Health Sciences, Netaji Subhash Chandra Bose Zonal Hospital, Mandi, Himachal Pradesh, India*
[2]*Dept. of Prosthodontics, Himachal Dental College, Sundar Nagar, Himachal Pradesh, India*

ARTICLE INFO

Article history:
Received 06-08-2020
Accepted 19-08-2020
Available online 24-09-2020

Keywords:
Bonemapping
Caliper
ComputedTomography
Implant
Implant placement

ABSTRACT

Background: In present times implants in modern dentistry are most reliable modality of treatment for restoration of partial or complete edentulous spans in patient's mouth. Aim of this article was to review already existing studies concerning evaluation procedures for dimensions of alveolar bone.
Materials and Methods: The through search was performed regarding existing literature available regarding bone/ridge mapping on various available platforms like science direct, Google scholar from 1992-2019 and the data obtained was assimilated along with concerned literature knowledge in the existing article.
Results: The various methods of assessing dimensions of residual bone were discussed thoroughly and in a simpler and clarified manner. Both direct and indirect techniques of bone mapping performed by an implant surgeon were detailed in a broader spectrum in this review article.
Conclusion: In this review article the earlier studies concerning bone mapping and diagnostic modalities for implant therapy were considered and the knowledge obtained was assimilated in this review. The results of indirect technique for bone mapping were found to be similar to those obtained from direct technique for bone mapping. However the bone mapping techniques possesses certain advantages over the radiographic techniques of assessing the bone dimensions.

1. Introduction

In the previous times, the various materials were used for replacement of missing human teeth included bone, carved ivory and even extracted natural teeth based upon the attachment mechanism to the human jaw. Similarly an alternative attachment mechanism was proposed first by Prof Ingvar Branemark et al during 1950s and 60s. The metal based component finally got attached to the jaw bone and this process of attachment was later termed by Branemark as osseointegration.[1] The dental implant treatment modality for rehabilitation of a partially or completely edentulous patient needs the appropriate steps to be taken by the operator for considering the patient as reasonable individual for the implant treatment.[2]

The prime motive of present treatment in dental implantology is rehabilitation of edentulous patient along with preservation of surrounding tissues and the treatment outcomes should be such that they can be predicted before hand, real in nature and status achieved can be maintained for the longer duration.[1] The osseointegration of the implant should be such that the restoration fabricated should be in harmony with the surrounding tissues.[2] The dental implant recipient bed should be thoroughly examined by dentist both clinically and visually and finally by different radiographic assessments.[3] The exact position and angulations of dental implant to be placed should be assessed by the clinician and prior to operating the clinician should acknowledge the available bone and shape of jaw along with surrounding anatomical structures.[4] In the ideal situation the implant should be surrounded by minimum of1mm of bone.[5,6]

* *Corresponding author.*
E-mail address: niti.sharma.ns80@gmail.com (N. Sharma).

https://doi.org/10.18231/j.aprd.2020.027

The different types of radiological investigations performed for diagnosis and treatment planning for dental implants includes intraoral periapical radiographs, panoramic and occlusal views, and computed tomography (CT).[1] In evaluation of available bone in case of anterior maxilla the clinician faces challenge with intraoral periapical and panoramic radiographs as results may be misleading due to image distortion and non recordibility of buccolingual cross sectional bone, however according to study performed by Lam and co-workers (1995) it was revealed that there is marked variance in bone height values in contrast with those obtained by panoramic radiographic techniques and 2 dimensional orthoradially formatted computerized tomographic images. The limitations of CT includes prolonged length of processing time i.e. 20 -25 minutes, exposure to higher radiation dose for head and neck region of the patient, the distortions in the images due to presence of metallic restorations and unnecessary patient movements while imaging and greater expense for economically poor patients.[5–7] The other methods of assessing the buccolingual residual ridge width for implant treatment includes trans tomography, ultrasonography and ridge mapping using direct caliper device during surgical procedure performed for exposure of underlying bone under local anesthesia.[8,9]

Previous literature highlighting the bone mapping procedures

Traxler M, Ulm C, Solar P, Lill W (1992)[10] determined from their study that ultrasound readings during sonographic measurements were similar to the data achieved at all the measuring points with that of ridge mapping technique.

Bruggenkate CM, de Rijcke TBM, Kraaijenhagen HA, Oosterbeek HS (1994)[11] suggested that the special caliper (ultimapper) devised to achieve accurate data regarding evaluation of residual bone width can be used for diagnosis before implant placement.

Bolin A, Eliasson S, Beetezen M, Jansson L (1996)[4] performed the study to compare the bone height available for implant placement at mandibular posterior sites by various radiographic techniques.

Almog DM, Sanchez R (1999)[12] revealed the inter-link within prosthetic sites and ridge curvatures and they found that disparity between prosthetic and ridge curvature was higher in posterior regions of the lower jaw.

Allen F, Smith DG (2000)[5] examined the preciseness regarding ridge mapping while treatment planning for implant placement in anterior maxilla. The outcome of this research suggested that mapping of residual alveolar bone was inadequate for precisely evaluating bone availability in anterior maxilla however it can provide accurate information if labial bone is not highly concave in contour.

2. Materials and Methods

The existing literature available regarding bone/ridge mapping in implant dentistry were searched by us on various platforms available on the internet like science direct, Google scholar from 1992 to 2019 and the knowledge gathered regarding the bone mapping in oral implantology and other diagnostic techniques were assimilated and compiled in a simpler form in this review article. The emphasis was made to gather the articles concerned to the bone mapping topic. The key words used in this search were bone mapping, caliper, computed tomography, implant, implant placement, diagnosis. The searches on the internet were made regarding the references of concerned articles of the bone mapping in oral implantology and diagnostic techniques and the important articles were downloaded and the knowledge gathered is imparted in this review article.

3. Discussion

The shape and appearance of the mucosa overlying the resorbed residual ridge might be deceiving the dentist about the accurate position and availability of bone required for placement of an implant.[13] The resorption of alveolar ridge is chronic, continuous, irremediable and cumulative. The degree of resorption of residual ridge is different in different patients and also varies in different region of maxillary and mandibular bone of the same patient.[10] The dental implant therapy requires the immense treatment planning as the implant based restorations are dependent for their function and esthetic appearance on the morphology of the residual bone and adaptation of an implant with the surrounding bone.[10] The evaluation of bone available before implant insertion includes necessary steps like proper diagnosis and treatment planning for the implant therapy. The dimension of bone which includes bone height can be assessed radiographically whereas the bone dimensions including (buccal-lingual) width should be assessed with tomography, ridge-mapping and computed-tomography imaging technique. The bone mapping method helps the operator to assess thickness of alveolar bone before implant placement hence this procedure avoids the change of treatment plan while operating due to lack of bone available for the placement of the selected implant.[1,11] The final outcome of esthetic and functional features of an implant restoration depend upon the preciseness of the implant placement technique as a minute variation in implant position leads to failure of the final restoration.[14,15]

The different methods used for evaluating (buccal and lingual) dimension of residual alveolar bone includes mapping of bone, CBCT imaging and direct caliper method used for evaluation of buccal and lingual ridge dimensions.[9]

3.1. Computed tomography

The radiological investigations are performed for pre-operative evaluation and diagnosis in an implant therapy; however such investigations are helpful for operator to avoid anatomical limitations and complications like sinus perforation in maxillary region and nerve parasthesia during implant placement. Although the different authors like Bragger, Akkesson and Hammerele suggested that overestimation or deficiency of the residual ridge were revealed repeatedly in the periapical radiographs and the panoramic views.[16] The computed tomography consists of the medical imaging modality, which includes production of 3- Dimensional reflections of concerned anatomy by reframing various axial-sections. This 3D imaging helps operator to bony topography, vital structures like nerves, sinuses, joints and other landmarks more efficiently than previous 2D imaging techniques. The recently framed CT scans can reveal axial images at 90^o to long axis of patient by revolving the radiation source, leads to emission of fan shaped beams 360^0around the patient. The machine receiver captures the radiation which are then transmit subject and the analysis in form of data is processed further by computer. This technique is helpful in imaging soft-tissues and blood vessels.[17]The computed tomography as a imaging modality in dentistry was first introduced by Schwartzetal was popularly termed as dentascan.[5]

3.2. Cone beam computed tomography CBCT

Limitations of this techniques includes greater radiation exposure to head and neck region, high cost involvement, large footprint and complexity in accessibility resulted in development of newer variant of CT which was CBCT.[18] The latest generation CBCT machines used particularly in the oro-facial region are modified so as to provide minimum radiation exposure to the patient. The CBCT technique utilizes a single 360^0 turn around the patient along with the cone beam while CT technique involves many rotations around the maxillofacial region utilizing the fan beam and multiple radiation exposure to the patient. The theoretical resolution values are greater in case of CBCT as compared with that of CT. Voxel size as index of resolution may be as low as 0.1mm in case of CBCT while this value may be 0.5 mm in case of CT.[17]

3.3. Ridge mapping procedure

The residual ridge mapping technique helps the implantologist to measure the dimension in relation to width of the remaining residual-bone of the patient.[1]

The bone mapping can be performed by the implant surgeon by two different techniques i.e.

1. Indirect technique
2. Direct technique

3.3.1. Indirect technique

The indirect technique for ridge mapping needs the lab fabrication of the guides. In this method the impressions of the patient were made and casts were prepared and the standardization of the height of cast were done i.e 25 mm by measuring with divider from cusp tip of surrounding teeth to the base of sulcus. The face-bow transfer was performed and cast assembly was mounted on semi-adjustable articulator. The wax up was made for diagnostic purpose and the point for implant insertion was marked by drilling through the artificial tooth upon the ridge as point C. Then the groove was made on buccal and lingual portion of cast to act as positive stop needed for putty index as acrylic is flown in the space. Spacer of modeling wax was prepared of 1 mm thickness with close adaptation to ridge with extension upto the previously marked grooves on buccal and lingual sides and after this step the silicone putty consistency was used for preparing the putty index and the wax spacer was removed. Then after application of separating medium the self polymerizing acrylic resin wax manipulated into the edentulous region after proper mixing and silicone index was fixed so that it is properly placed over groove. After polymerization completion the guide was removed from cast and trimmed and polished properly to remove excess resin and fins.[15]

Preparations of the points on the cast were done by placing the guide on the edentulous span on the cast and point C was indented on crest of alveolar bone. From this point C, 3mm away on buccal and lingual sides of ridge point B_1 and L_1 are marked and similarly from these points another two points B_2 and L_2 were again marked at the distance of 6mm from the point C on buccal as well as lingual sides respectively. (Figures 1 and 2)

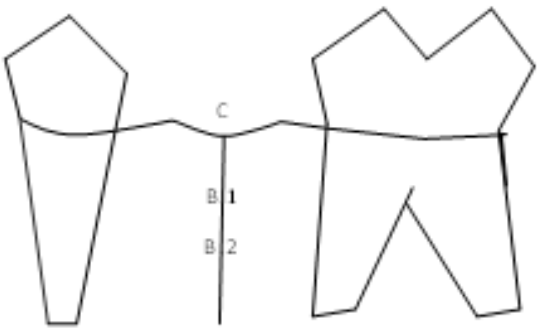

Fig. 1: Markings on the buccal side of ridgeand location of implant position on ridge.

The all the mentioned points were shifted to the acrylic guide and holes were made on the respective points with the help of no. 6 round straight bur. The cast was sectioned using saw along the line from point C to B_1 and B_2 on buccal side and from point C to L_1 and L_2 on lingual

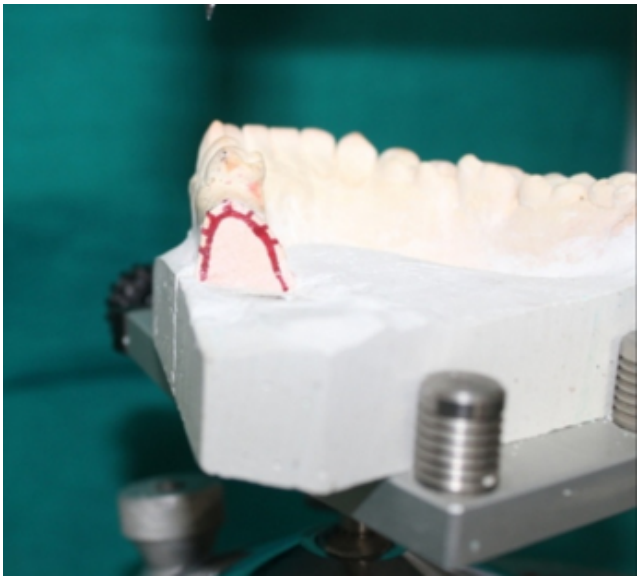

Fig. 3: Measurements performed at all the marked points and the transferred to the cast for measuring (buccal-lingual) ridge width.

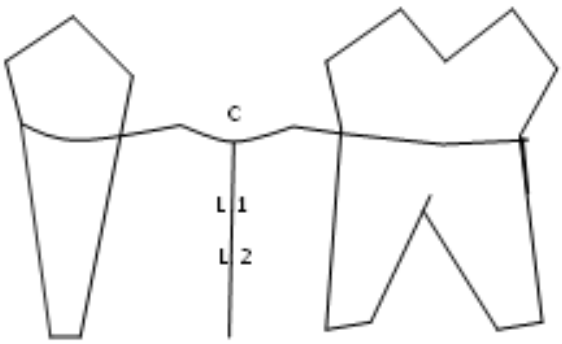

Fig. 2: Markings on the lingual side of the ridge and location of implant position on the ridge.

side of the ridge.[1] The ridge mapping procedure was the performed after proper disinfection of acrylic guide in 2% gluteraldehyde for 10 minutes and washing under water. The topical anesthesia was applied over the edentulous site and guide was seated over this region. After achievement of anesthesia the sterile endodontic file no. 15 instrument was inserted via hole corresponding to point C and pushed with gentle pressure to contact the underlying bone and the stopper was brought in the contact with the guide. Then after removing the file gently out the same instrument was held in contact with the cut surface other cast at point C and the tip of the instrument contacting the surface was marked with pencil on the cut surface of the cast. Similar procedure was repeated for all the other points to achieve simultaneous points on the sectioned surface of the cast. All the point marked on the cut surface joined with pencil to achieve pattern of the available bone for insertion of an implant. The alveolar bone accessible for insertion of an implant can be measured with divider on the sectioned surface of the cast between corresponding points of point B_1 and L_1 and B_2 and L_2 respectively.[15] (Figure 3)

3.3.2. Direct Technique

In direct technique method bone width is measured directly in patient mouth with the help of bone caliper device from the point marked as bleeding spots in the indirect method. On the completion of the measurements the operated area is cleaned and blood is wiped off with the application of sterile gauge.[11,15]

4. Conclusion

In this review article the previous studies regarding the bone mapping and various diagnostic modalities regarding treatment plan for implant therapy were considered and the knowledge obtained was assimilated in this review. The results of indirect technique for bone mapping were found to be equivalent to those of direct technique for bone mapping. However the advantages of the bone mapping techniques are these techniques are easy to perform along the chair side, economic for the operator and patient and without involvement of the exposure to radiation as compared to the CT and CBCT techniques for measuring the residual bone of the patient. The ridge mapping results obtained by the operator prevents unexpected change in treatment plan during implant placement procedure due to lack of adequate bone to support the previously planned implant.

5. Source of Funding

None.

6. Conflict of Interest

None.

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Author biography

Nitin Sharma Medical Officer Dental

Archana Nagpal Professor and Head

Ijaz Ahmad Bhat Post Graduate Student

Cite this article: Sharma N, Nagpal A, Bhat IA. **Bone mapping as a diagnostic approach in Oral Implantology** . *IP Ann Prosthodont Restor Dent* 2020;6(3):130-134.