Journal of Pharmaceutical Research International

33(49B): 80-88, 2021; Article no.JPRI.76566
ISSN: 2456-9119
(Past name: British Journal of Pharmaceutical Research, Past ISSN: 2231-2919, NLM ID: 101631759)

Diagnosis and Treatment Planning for Dental Implants – A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i49B33342
Editor(s):
(1) Mohamed Salem Nasr Allah, Weill Cornell Medical College, Qatar.
(2) Ana Cláudia Coelho, University of Trás-os-Montes and Alto Douro, Portugal.
Reviewers:
(1) Eri Hendra Jubhari, Hasanuddin University, Indonesia.
(2) Rachna Jain, Gian Sagar Dental College and Hospital, India.
(3) R. S. Pavithra, Tamilnadu Dr. M.G.R Medical University, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/76566

Review Article

Received 28 August 2021
Accepted 03 November 2021
Published 12 November 2021

ABSTRACT

Establishing and arriving at a diagnosis is the key to treatment planning and often practitioners tend to create a treatment plan overlooking the fundamental principles that must be taken into consideration prior to performing implant surgeries. The sequential process of clinical examination, laboratory tests, radiographic analysis, diagnostic protocols, casts wax ups, along with the treatment needs and desires of the patient have to be factored in for the overall diagnosis and prognosis of implant therapy. A step-by-step methodology has been created to help the implant practitioner with a checklist that aims to create the optimal treatment plan for each case.

Keywords: Treatment planning; CT scan; Surgical guides.

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1. INTRODUCTION

Oral implantology (implant dentistry) is the science & discipline concerned with the diagnosis, design, insertion, restoration & management of alloplastic or autogenous oral structures to restore the loss of contour, comfort, function, esthetics, speech & health of the partially or completely edentulous patient. Implant prosthodontic is the branch of implant dentistry concerning the restorative phase following implant placement & the overall treatment plan component before the placement of dental implants [1].

The objective of the treatment planning is to form an organized documentation of the patient's pre-treatment condition leading to treatment option in phases. The treatment phases can then be completed in a sequence that is consistent with what is clinically appropriate and compatible with the patient and clinician's schedule. A good rapport between patient – doctor, a thorough comprehensive written evaluation and a multiphase treatment plan certainly leads to successful surgical and prosthetic complex restorative cases [1]. This process can take place over a period of 1-3 pre-treatment appointment. This way the patient better understands the treatment options and risks vs benefits, thus appropriate informed consent is attained making the treatment acceptable and providing the treatment much more effectively and delivering it more efficiently [2].

1.1 Rationale for Implants

The clinical replacement of lost natural teeth by osseointegrated implants has represented one of the most significant advances in restorative dentistry [3].

The increased need and advantages of implant supported and retained restorations are a result of many factors which can be divided into four categories:

1. Preservation of tooth structure
2. Preservation of bone
3. Provision of additional support
4. Resistance to disease

1.2 Anatomic Problems Associated with Edentulism

- Decrease width of supporting bone
- Decrease height of supporting bone
- Prominent mylohyoid & internal oblique ridges
- Progressive decrease in attached mucosa
- Prominent superior genial tubercle
- Forward movement of prosthesis from anatomic inclination
- Elevation of prosthesis with contraction; mylohyoid & buccinators muscles serving as posterior support
- Thinning of mucosa with sensitivity to abrasion
- Loss of basal bone
- Paraesthesia from dehiscent mandibular canal
- Increase in size of tongue
- More active role of tongue in mastication
- Decrease of neuromascular control with aging
- Effect of bone loss on esthetic appearance of face [4]

2. MEDICAL EVALUATION

In medically healthy patients, the success rates of some dental implant (DI) systems have reported to be between 90 and 95% at 10 years [5].

The longer term outcome of implant therapy can be affected by local or systemic diseases or other compromising factors, in fact, it has been suggested that some local and systemic factors could represent contraindications to DI treatment [6-9].

An arbitrary but practical method of patient selection may be based on the American Society of Anesthesiology's Classification (ASA). This classification defines the limits of risk factors for five categories of patients. As both implant and preprosthetic procedures are elective surgeries aimed at restoring function and comfort of patients, they should be restricted to ASA1 (patients with no health problems) and ASA2 (patients with minor health problems who respond well to treatment). Any patient whose health condition places him in Category ASA3 (major health problems with partial correction) or higher should be carefully screened for relative contraindications or possibly absolute contraindications [10].

Relative contraindications for Dental implant, certain patient groups or conditions: [6]

- Children & adolescents

- Epileptic patients
- Severe bleeding tendency
- Endocarditis risk
- Osteoradionecrosis risk
- Myocardial infarction risk

Chart 1. American society of anesthesiologists physical status classification

American Society of Anesthesiologists (ASA) Classifications
ASA I: A normal, healthy patient, without systemic disease.
ASA II: A patient with mild to moderate systemic disease.
ASA III: A patient with severe systemic disease, which limits or alters activity but is not incapacitating.
ASA IV: A patient with severe systemic disease, which is incapacitating and is a constant threat to life.
ASA V: A moribund patient not expected to live more than 24 hours without an operation.
Elective implant surgeries are not indicated for ASA IV or V patients.

2.1 Possible Contraindications [11,12]

- Alcoholism
- Bone disease
- Cancer patients
- Cardiac disease
- Corticosteroids
- Diabetes
- Hyposalivation
- Immunocompromised patients
- Mucosal disease
- Titanium allergy

2.2 Extraoral Examination

Extraoral examination allows for evaluation of facial symmetry, skeleton profile, facial contours, patient's speech & lymph nodes, etc.

2.3 Intraoral Examination

Intraoral examination is visual as well as palpation process. Intraoral soft tissue is examined for any pathology. Evaluationof tongue and para functional tongue habits should be examined along with lateral and frontal tongue thrust and factors of force. Muscle attachment on buccal or lingual aspect of natural teeth or implant site should be evaluated.

2.4 Dental Evaluation Factors of Force

- Normal biting forces
- Para functional forces
- Clenching
- Tongue thrust
- Position of arch
- Direction of load
- Crown implant ratio
- Bone density

2.5 Periodontal Evaluation

Periodontal evaluation includes periodontal charting, periodontal disease, classification and documentation of the location of quantity of keratinized attached gingiva. Bone loss, i.e. vertical or horizontal defect should be carefully mapped on the chart or any gingival recession on maxillary or mandibular teeth should be examined. Oral prophylaxisis of patient should be inspected for plaque or calculus. The patient should be radiographically and clinically evaluated with a comprehensive periodontal examination.

2.6 Anatomy of Bone for Implant and it's Evaluation

The Skeletal profile has both esthetics as well as well-functional ramifications. The patient should be evaluated aesthetically while inspecting the edentulous arch. Skeletal profile classification relating the maxilla and the maxillary arch to themandible and the mandibular arch is done with visual inspection , mounted study models and by cephalometric radiographs.

Mounted study models can assist in properly evaluating the arch form as well as inter arch relationship. The arch geometry impacts the position of dental implants, thus impacting the way the implants relate to each other in an antero-posterior direction.In a V shaped arch would land more easy to place implants with a great anterior-posterior ratio than a U-shaped arch or an arch with straight anterior ridge. In a tissue-supported over denture when using two implants, they are placed closed together in a V-shaped edentulous ridge as compared to U-shaped or square shaped ridge [13,14]. Interocclusal opposing abutments relationship should also be considered,as greater the resorption the maxillary arch is more lingually placed to mandibular arch. The Interocclusal arch distance is the distance between the arches in a vertical direction. It may become over closed due to supra-eruption of the dentition into an

edentulous space or posterior displacement of the condyleor wear of dentition as a result of loss of alveolar bone. This condition results in prosthetic challenge when there is a significant loss of alveolar bone, onlay grafts followed by softtissue reconstruction may be considered to fulfill the patient'sexpectations. This would require several surgical procedures to achieve the expected results. The implantologist should also take the phonetics in to consideration while planning edentulous arch [15].

2.7 Occlusion

The patient should be examined for the changes in occlusion due to the missing teeth. There may be premature contacts or major occlusal discrepancies due to trauma to occlusion. The patient's existing occlusion should be evaluated. In conjunction with the development of the treatment plan it is also necessary to create a diagnostic wax-up to determine spatial relationship (mesial, distal, buccal, and lingual) as well as the alignment and parallelism of the implants to be placed. In the edentulous space the tooth or teeth are fabricated using a baseplate. The diagnostic wax-up is duplicated into a stone model and a surgical template is fabricated to assist the surgeon in proper alignment, parallelism and direction of implants. The cuspid relationship as well as posterior tooth contact in centric as well as eccentric relationship should be documented. The patients over bite and over jet are measured along with the curve of Spee and curve of Wilson on the mandibular arch. Proper occlusion should be based on bioengineering principles that will support that individual patient's stomatognathic system and abutment prosthesis apparatus [16].

2.8 Radiographic and Imaging Examination

Diagnostic imaging can play an important role in evaluating the dental implant patient. Imaging studies can include basic plain radiography eg. dental panoramic radiography as well as advanced studies such as computed tomography (CT) and reformatted cross-sectional, panoramic, and 3D imaging. Information obtained from advanced imaging studies is often used to determine if a patient is suitable for implant placement, the appropriate site(s) for implant placement, the size of implant that can be placed, and the need for possible pre-implantation ridge surgery. Postoperatively, advanced imaging studies can show the failure of an endosseous implant to osseointegrate, improper placement of an implant, and violation of important structures e.g., the mandibular canal, nasal cavity, or maxillary sinus [17].

The bone should be visualized in all possible dimensions so that accurate data can be gathered and jaw anatomy can be visualized before implant placement. Naturally, the implant should be away from neurovascular bundles and anatomic sinuses to avoid perforations and the resultant complications [18].

Many imaging modalities have been reported to be useful for dental implant therapy including.

2.9 Panoramic, Cephalometric and Tomographic Radiography, Computed Tomography (CT), Interactive CT and Magnetic Resonance Imaging (MRI)

2.9.1 Use of steel radio opaque marker

The OPG may undergo distortion and can lead to erroneous determination of the available bone height and selection of wrong implant length. Hence, a calibration of the OPG is required for more near accurate determination of the available bone height. The simplest method uses a radiographic marker or a steel ball bearing of known diameter when taking OPG. The actual available height can be calculated using the following formula:

$$\text{Actual height of the bone} = \text{Actual diameter of the marker} \times \frac{\text{Radiographic length of bone}}{\text{Radiographic diameter of marker}}$$

2.10 Edentulous Ridge

The edentulous area present in the patient's mouth is further evaluated. Classification is described by Misch and Judy describing edentulous ridge as given below:

2.11 Divisions of Bone

- Division A—5 mm wide 10 mm length (root form implants are usually the implant of choice)
- Division B—2.5 mm wide 10 mm length (blade or graft)
- Division C-W unfavorable width
- Division C-H unfavorable height
- Division D (subperiosteal, illiac crest or sinus lift).

Table 1. Bone density classification and common locations

D1	Dense cortical bone	Anterior mandible Posterior mandible
D2	Dense to porous cortical bone surrounding dense trabecular bone	Anterior mandible Posterior mandible Anterior maxilla
D3	Thin porous cortical bone Surrounding fine trabecular bone	Anterior maxilla Posterior maxilla
D4	Fine trabecular bone	Posterior maxilla

Table 2. Available bone considerations

Length	Mesio-distal dimension
Width	Bucco-lingual dimension
Depth	Ridge crest to nearest anatomic landmark

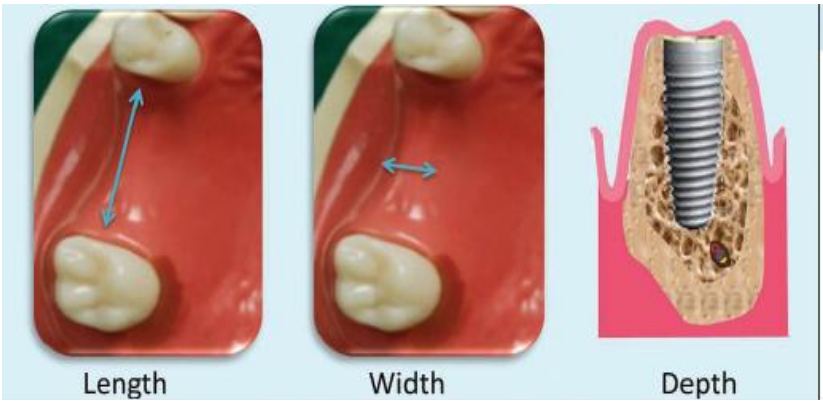

Fig. 1. Available dimensions of bone (Source : Journal of Interdisciplinary dentistry)

2.12 Bone Density

Bone density is a key determinant in treatment planning,implant design, surgical approach, healing time, and type of loading during prosthetic reconstruction. Four types of mineralized bone have been described by Misch. It may be determined by the general location, radiographic evaluation, and tactile sense during surgery [19].

2.13 Available Bone

Available bone is that portion of a partially or totally edentulous alveolar ridge that can be used to insert an endosteal implant (Fig.1). The available bone has three dimensions: Length, width, and depth. (Table 2).

2.14 Spacing Requirements

The following guidelines should be used when selecting implant size and evaluating mesiodistal space for implant placement:[20]

• The implant should be at least 1.5 mm away from the adjacent teeth.
• The implant should be at least 3 mm away from an adjacent implant.
• A wider diameter implant should be selected for molar teeth because of the high occlusal loads.
Spacing is required to provide the following:
• To allow for 1.5 mm of crestal bone interproximally, this in turn will allow for proper development of a healthy papilla [21-23].
• To develop proper contacts and the contours in the restoration.
• To allow for an adequate width of soft tissue between implants and adjacent teeth [24].
• For the prosthetic components not to impact on each other [24]
• For the effective cleaning of the prosthesis by the patient [24]
• To develop harmonious occlusion.
• To allow for at least 1 mm space from the implant to the adjacent root.

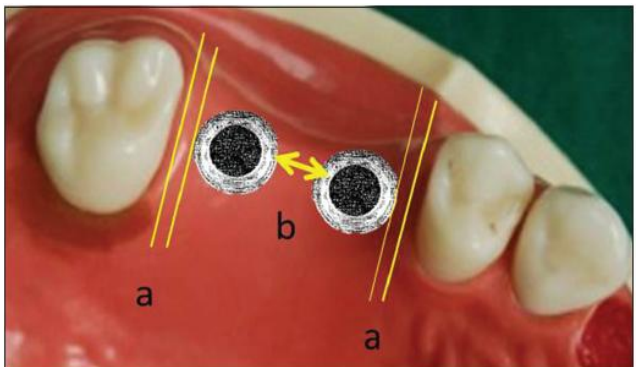

Fig. 2. Implant spacing guidelines (a = 1.5 mm, b = 3 mm)
(Source: Journal of Interdisciplinary dentistry)

Table 3. Guidelines for spacing requirements

The implant should be at least 1.5 mm away from the adjacent teeth
The implant should be at least 3 mm away from an adjacent implant
>1 mm bone should be present on the facial and lingual aspect of the implant

3. AVAILABLE BUCCOLINGUAL BONE WIDTH

The available bone width is measured from the facial cortical plate to the lingual cortical plate at the crest of the prospective implant site.

The minimum available bone width should be such that >1 mm of bone should be present on either side of the implant facio-lingually to keep the soft tissue levels stable .This is critical on the facial side since anybone resorption and ensuing change in the position of the gingival margin will be non-esthetic [23]. Considering the above guideline, in an ideal situation the implant diameter chosen should be at least 3 mm less than the available mesio-distal dimension of the bone and 3 mm narrower than the bucco-lingual dimension of bone.

3.1 Visual Assessment and Palpation

The height, buccolingual width, and contour of the ridge can be visually assessed. The careful palpation of the ridgewill detect any presence of concavities. If the overlying tissue is fibrous or thicker, accurate assessment may bedifficult with visual assessment and palpation.

3.2 Ridge Mapping

Ridge mapping is a procedure that allows the implant surgeon to determine the thickness or width of the alveolar bone [21]. In this technique, a needle with an endodontics topper or a specially designed caliper is penetrated through the soft tissue in the area under evaluation for implants. The soft tissue thickness at the ridge crest, at two points vertically down on the buccal and the lingual areas is measured. The edentulous area of the diagnostic cast is sectioned perpendicular to the ridge. The tissue thicknessis then mapped out on the sectioned diagnostic cast using a pencil . This gives an idea of approximate ridge width as well as a rough estimation of the ridge contour. Even though it gives better picture of the ridge profile than visual assessment, it is still prone to error.

3.3 Crown Height Space

Crown height space is considered as the key vertical parameter in treatment planning for the implant restorations. The crown height space is the distance from the occlusal plane to the crest of the alveolar ridge in the posterior region and from the incisal edge of the arch in question in the anterior region [19]. This will influence the type of prosthesis, material choices, andsurgical technique that will be used.

This factor is often overlooked until the prosthetic phase. A satisfactory restorative outcome is obtained only if adequate crown height space is available. To provide sufficient room for the prosthetic components, an adequate space should be present between the edentulousridge and the opposing dentition. Ideally, for cement retained prosthesis 8-12 mm crown height space is needed, measuring from

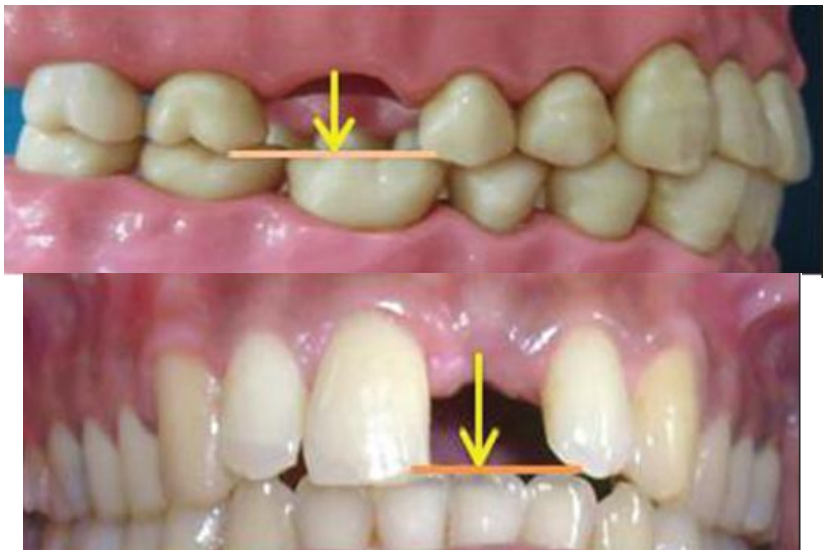

Fig. 3. Crown height space (Source: Journal of Interdisciplinary dentistry)

the soft tissue of the edentulous ridge to the occlusal plane at the middle of the implant receptor site [19].

The ideal vertical dimensions of each region are 3 mm for the soft tissue, [25] 5 mm for the abutment height, [19] and 2 mm for the occlusal metal or porcelain. The screw retained restorations generally require lesser crown height space compared to the cement retained prosthesis since it can screw directly onto the implant body.

The consequences of inadequate crown height space include a decrease in abutment height, inadequate bulk of restorative material for strength and esthetics, and poor hygiene conditions.

If there is inadequate crown height space, the use of metal occlusal surface may be required which may be least esthetic option. However, when heavy occlusal forces are expected, metal may be the preferred choice of restoration.

When the available space is inadequate due to over eruption of the opposing teeth, depending on the extent of available space minimal enameloplasty, orthodontic intervention, elective endodontics, crown lengthening, and crown in the opposing quadrant may be indicated.(Fig.3).

4. AVAILABLE BONE HEIGHT

The height of the available bone is measured from the crest of the edentulous ridge to the anatomical landmarks that limit the placement of the implant. The assessment of implant length should allow an adequate safety margin of approximately 2 mm, particularly as many drills are designed to prepare the implant site slightly longer than the chosen implant. There should be at least 2 mm of bone between the apical end of the implant and neurovascularstructures.
The anatomical structures to be considered before planning the implant length are as follows:

• In the maxilla: Floor of the maxillary sinus, floor of the nose
• In the mandible: Mental foramina, roof of the inferior alveolar canal, submandibular fossa
• Teeth: Adjacent tooth roots.

These landmarks can be outlined directly on a periapical and panoramic radiograph to clearly indicate the amount of available height of bone.

5. SURGICAL GUIDE TEMPLATE

Surgical guides are fabricated after the diagnosis and prosthetic planning. They guide the surgeon for precise positioning and angulation of the implant during placement in relation to remaining natural dentition and residual alveolar ridges. The surgical guide should be stable and rigid when positioned in the mouth. It should be easy to place and remove. It should not be bulky and must not interfere with tissue reflection, visualization of surrounding landmarks. Also, it should be transparent and allow easy access for the surgeon [19].

The surgical guides can serve dual purposes as both radiograph measuring device and a surgical

guide. There are several methods of fabricating the surgical guide templates.

6. CONCLUSION

Implant supported restorations provide considerable advantages over other available treatment options and,therefore, must be considered as a treatment option for restoration of missing teeth. The implant is placed in an optimal position to effectively support the restoration and surrounding soft and hard tissues. The clinician must carefully evaluate all the factors outlined to ensure a long term predictable outcome.

CONSENT

A rule of thumb in dentistry should be to obtain a signed,written informed consent from the patient for all the procedures. Treating a patient without informed consent amounts to negligence. Irrespective of the best efforts,unforeseen complications can sometimes occur on the dental chair. A signed, written informed consent can serveas the evidence for any legal issues.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/76566