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Implants Guidelines for Restorative Dentists

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Dentistry and oral health care has evolved over the course of time from a primitive form of medicine to modern day use of preventative dental care, state of the art diagnostics and modern age treatment¹. During the past several centuries, dentistry had seen many improvements and changes especially in the area of replacing missing teeth. Traditionally, treatment modalities for tooth loss include removable partial dentures (RPDs) and fixed partial dentures (FPDs)^{2,3}. Removable partial denture is cheap and easy to fabricate. Furthermore, it helps in the restoration of appearance, improved masticatory function, prevention of undesirable morphological effects of tooth loss including alveolar bone resorption, alteration of the occlusal plane and movement of the remaining teeth^{4,5,6}. However, research has shown that it is less acceptable to patients and has been associated with some significant adverse complications such as plaque accumulations, increased incidence of caries and periodontal breakdown, occlusal loading of soft tissues, gingival discomfort and direct trauma^{6,7,8}. Fixed partial dentures are more acceptable than RPDs, but may involve preparation of intact teeth which may sometimes lead to pulpal necrosis⁹.

In modern era, dental implants have become increasingly useful in the management of tooth loss¹⁰. The clinical success of implant therapy in edentulous and partially edentulous patients is well documented^{11,12} and many clinicians realize the benefits of adopting implant therapy in their practices. Research has shown that they are acceptable and improve quality of life when compared to RPDs and FPDs^{10,13,14}. Dental implants are inert, alloplastic materials surgically inserted into the residual alveolar ridge of the maxilla and/or mandible for the management of tooth loss and to aid

replacement of lost orofacial structures. The most common type of dental implant is endosseous¹⁵, comprising a discrete, single implant unit (screw- or cylinder-shaped are the most typical forms) placed within a drilled space within dento-alveolar or basal bone to serve as foundation for prosthodontic restoration. The clinical situations in which dental implants are used have increased tremendously over the past several years from merely treating completely or partially edentulous patients to treating people with extensive loss of oral and facial tissues¹⁵. Dental implants have been shown to be a highly successful and predictable treatment modality for replace missing teeth by providing adequate support to crowns, bridges, dentures and obturators^{16,17}.

The advantages of implant over other treatment modalities include no preparation of tooth/adjacent teeth, bone stabilization and maintenance, retrievability, improvement of function, improved support, a more stable occlusion, simplification of the prosthesis and psychological improvement¹⁸. Disadvantages include risk of screw loosening, risk of fixture failure, length of treatment time, need for multiple surgeries and challenging aesthetics^{19,20}.

History of Implant

Dental implants date back thousands of years during the ancient Chinese, Egyptians, Greeks and Etruscans civilizations. History shown then that it has always made sense to replace a tooth with an implant in the approximate shape of a tooth. About 4000 years ago, Chinese carved bamboo sticks in the shape of pegs and drove them into the bone for tooth replacement. Also, skulls of Egyptians dated to more than 2000 years ago showed peg shaped precious

metals inserted in the jaws obviously to replace missing teeth. A skull was found in Europe with a ferrous metal tooth dated back to the time of Christ. Pieces of seashells were carved by the Incas from Central America and inserted into the jaw bones to replace missing teeth²¹.

Various attempts were made at developing tooth replacement implants in the late eighteen and nineteen centuries but were met with failures. For example a prototype of the hollow cylinder implants used today, and made of an iridium-platinum alloy was first introduced by Greenfield in 1906. Around 1930s, it was reported that Strock²² anchored a vitallium (cobalt-chromium molybdenum alloy screw) within bone and immediately loaded the implant with porcelain crown. Also, Mueller was credited with the placement of an implant, made of iridium platinum. From the 1950s, numerous implantologists began to develop implant procedures²¹⁻²⁵.

Modern oral implantology began when Branemark, a physician was conducting experiments in vivo using Titanium chambers placed within bone, discovered the particular connection this metal was able to develop within the recipient tissue²⁶. In 1965, Branemark proposed a "bone-anchored bridge" to treat edentulous mandibles. The concept of osseointegration was originally proposed and developed in two fundamental publications²⁷⁻²⁹. Following one year of observation, no inflammation was detected in the peri-implant bone; meanwhile, soft tissue had formed an attachment to the metal(titanium) and bone³⁰. As a result of Branemark's extensive studies, titanium has become the gold standard in implant dentistry. However, the great revolution in the field of ceramic materials with the use of zirconium dioxide and also other materials has opened a new, challenging way in implantology.

Implant Biomaterials and properties

Commercially, pure titanium (CpTi) and extra low interstitial Ti-6Al 4V (ELI) are the two most common titanium based materials³¹. The evolution of titanium as a biomaterial for implant has dramatically increased in the past few years because of its favourable combination of mechanical strength, chemical stability, and biocompatibility³².

The first generation of titanium implants, which were machined with a smooth surface texture presented a history of 50 years of success. As the implant surfaces were recognized to play an important role in molecular interactions, cellular response and osseointegration, the second generation implants were developed with surfaces which can accelerate and improve implant osseointegration. To enhance early osseointegration, nanoscale features that have the ability to induce the differentiation of stem cells along the osteogenic pathway and help cell attraction and adhesion to extracellular matrix causing clustering of integrins into focal adhesion complexes (FA), and activate intracellular signaling cascade, all leading to a better osseointegration were developed³³. These second generation of clinically used implants underwent mechanical blasting coupled or not, with acid etch, bioactive coatings, anodized

and, more recently, laser modified surfaces³⁴. The properties of titanium are lightweight, biocompatible, corrosion resistant (dynamic inert oxide layer), and good strength.

However, alternative materials include ceramics such as aluminum oxide and other alloys (gold and nickel-chrome-vanadium). Ceramic materials for oral implants were already investigated and clinically used some 30–40 years ago^{35,36}. Research and manufacturing technology have allowed production of advanced bioceramic. Initially, the ceramic material utilized was aluminum oxide (Alumina), but the introduction of new materials such as Yttria, partially stabilized tetragonal Zirconia polycrystals (Y-TZP), Zirconia toughened Alumina (ZTA), and new manufacturing techniques such as Powder Injection Molding (PIM)³⁷ and Hot Isostatic Pressing (HIP) have revolutionized the field of bioceramics. Currently the material of choice is Yttria-stabilized tetragonal Zirconia polycrystal (Y-TZP). However, a newly proposed ceramic material is Ce-TZP (ceria stabilized TZP)^{37,38} but neither in-vitro data, nor in-vivo tests have been published so far.

Treatment Guidelines

A key principle of implant treatment is that the placement of implant should be prosthetically driven³⁹. Hence, implant fixture placement and the design of the final prosthesis must align with the goal of treatment which is to improve function and aesthetics without compromising oral hygiene and the health of the remaining oral tissues⁴⁰.

Patient selection

As with other areas of dentistry, careful patient selection is a prerequisite for overall success. Care must be taken to properly assess and select the right type of patient for treatment. There are very few absolute medical contraindications for dental implant treatment. Some of these are: Inability to maintain good oral hygiene after repeated motivation, History of periodontal disease, Presence of intraoral pathology or malignancy, Drug and alcohol abuse, Recent history of myocardial infarction, stroke or valvular prosthesis surgery, Intravenous bisphosphonate (anti-resorptive) therapy, Immuno compromised patients following organ transplant or treatment of systemic disease.

Other conditions considered as relative contraindications are:

1. Age and Gender: There is no convincing evidence to suggest that age or gender affect the outcome of osseointegration in the short or long term⁴¹. This is somewhat a surprising finding, given that, a sudden decline in bone volume and bone mass occurs as a result of ageing and particularly in postmenopausal women. However, younger patients may show greater crestal bone resorption around dental implants⁴². It is therefore recommended that implant placement be delayed until growth and development have ceased or are minimal⁴³. For this reason implants are not placed until the facial skeleton has stopped growing; this being usually about 18 years of age. However, implant failure does not correlate with age⁴¹. Increasing age has no effect on osseointegration or the rate of crestal bone resorption around dental implants⁴². Therefore, increasing age is not a barrier to successful dental implants, although

medical conditions associated with increasing age may require modifications to the implant treatment plan.

2. Smoking: There is strong evidence that smoking interferes with osseointegration^{44,47}, and it is also associated with high risk of poor wound healing, peri-implant infection⁴⁸ and accelerates bone resorption around dental implants^{49,50}. There is a consensus that smoking could increase the risk of complications from poorly controlled diabetes, immunosuppression and, untreated periodontal disease. Smoking cessation during the healing phase following implant surgery improved implant survival⁵¹. Hence conventional denture or fixed partial prosthesis may be preferable to dental implants for patients who continue to smoke.

3. Diabetes Mellitus: Studies have shown reduced bone contact area and bone thickness around hydroxyapatite and titanium implants in diabetic rats⁵²⁻⁵⁵, and significantly less bone-to implant contact in the insulin-controlled diabetic rats compared with normal rats⁵⁶. However, insulin therapy has been shown to increase peri-implant bone formation in the diabetic rat model. A study suggested that diabetic patients who are well controlled with insulin are suitable for implant surgery under antibiotic cover⁵⁷. Also many studies have reported implant success in diabetic patients⁵⁸⁻⁶⁰. In a recent retrospective study, the survival rate of dental implants in controlled diabetic patients was slightly lower than that documented for the general population. The increased failure rate occurred during the first year following prosthetic loading⁶¹. It is concluded that dental implants are usually successful in patients with diabetes, however, uncontrolled diabetes contraindicates dental implant placement.

4. Osteoporosis: Osteoporosis is a progressive systemic disease characterized by low bone mass and deterioration of bone tissue, leading to bone fragility and fracture⁶². The prevalence of osteoporosis increases with age and after menopause. The effect of osteoporosis on implant success has been widely studied. A study showed that steroid-induced osteoporosis had no effect on mandibular implants in rabbits⁶³. Another report described successful implants in an 80-year-old female with severe osteoporosis and chronic polyarthritis receiving methotrexate disodium and acemetacin⁶⁴. Hence on the balance of evidence, osteoporosis appears not to influence implant survival^{65,66}. Moreover, dental implants may actually stimulate mandibular bone formation in a load-dependent manner⁶⁷.

5. Osteoradionecrosis: Head and neck irradiation following dental implant placement carries a significant risk of osteoradionecrosis⁶⁸. Many studies have examined implant experience in head and neck radiotherapy patients with varying degrees of failures ranging from 5% - 30%⁶⁹⁻⁷². Some authors have recommended a 6 to 12 month recovery period after irradiation prior to dental implant placement⁷³. Pre-surgical hyperbaric oxygen have been shown to reduce the rate of dental implant failure in irradiated jawbone from 60% to 5%⁷⁴. Whatever the method, strict long-term follow-up is required to monitor the condition of the peri-implant tissues when implants are placed in irradiated jawbone. Similarly, if irradiation is to be performed in areas where titanium implants have been placed, it is recommended that

all prostheses, frameworks and abutments be removed before irradiation. Osseointegrated implants can remain in situ, although they should be covered with skin or mucosa⁶⁸.

6. Oral lesions: Oral lesions such as oral lichen planus (OLP) are associated with the Koebner phenomenon, and surgical trauma is known to exacerbate oral lesions⁷⁵. Hence, dental implant surgery may exacerbate OLP lesions. Endosseous dental implants may be used in patients with non-erosive forms of OLP, although patients should be warned of possible lesion exacerbation related to surgery and possible implant failure if gingival lesions become erosive. There is little or no scientific information on dental implants and oral mucosal diseases including recurrent aphthous ulcer, stomatitis, pemphigus vulgaris, cicatricial pemphigoid, discoid lupus erythematosus, erythema multiforme, hyperkeratosis, dysplasia, herpes zoster, or recurrent oral herpes. Little is known about endosseous dental implants and oral bone diseases including sclerosis and exostosis, Paget disease, fibrous dysplasia, cherubism, osteomalacia, hyperparathyroidism, Langerhans cell histiocytosis, or central giant cell granuloma.

7. Human Immuno-deficiency Virus (HIV): Patients with AIDS may be at greater risk of peri-implantitis, endosseous dental implants have been placed successfully in HIV-positive patients⁷⁶. Diligent hygiene and long-term follow-up are required for implants placed in HIV-positive patients.

8. Patient on drugs for systemic diseases: Placement of implant is contraindicated in patients undergoing cytotoxic chemotherapy. Furthermore, peri-implant soft tissue hyperplasia is said to occur in patients taking dilantin sodium (phenytoin) or nifedipine^{77,78}. Therefore, careful follow-up of dental implant patients taking calcium channel blockers or other drugs associated with gingival hyperplasia is essential. Also, patients taking anticoagulants (including aspirin) are at risk of severe hemorrhage during implant surgery. Patients on long-term systemic corticosteroids are at risk of steroid crisis during implant surgery. Furthermore, steroid-induced osteoporosis may complicate dental implant treatment⁶⁶. Hence consultation with the patient's physician prior to dental implant placement is desirable for patients on anticoagulants or long-term systemic corticosteroids.

9. Periodontal disease: Implant treatment in individuals with periodontitis-associated tooth loss is frequently debated. Many of previously published systematic review articles believed that there are not enough evidence to suggest that patients with periodontitis may not benefit from implant treatment⁷⁹⁻⁸¹. Another systematic review noted that the survival rates are high for supra structures and implants in individuals with a history of periodontitis-associated tooth loss but concluded that Implant treatment in periodontitis-susceptible patients is not contraindicated. However, the higher incidence of peri-implantitis may jeopardize the longevity of the implant treatment. Therefore, implant treatment in periodontitis-susceptible patients has to include adequate infection control and an individualized maintenance programme⁸².

10. Occlusal conditions and loading: Patients with previous history of heavy occlusal load require careful long-term management and monitoring of their occlusion because dental implants lack the benefit of a periodontal ligament and

its proprioceptive function. Natural teeth are supported by periodontal ligaments with receptors that help protect teeth and the periodontium from excessive occlusal forces that can cause trauma to the supporting bone^{84,85}. These neuromuscular reflexes are absent in osseointegrated implants. Hence, a poorly developed occlusion on implant-supported restorations could have a deleterious effect on the supporting bone as well as on the accompanying prosthesis components⁸⁶. Opinion varies as regards the effect of occlusal forces and implant. While some authors believed that occlusal overloading was the primary reason for bone loss around implants^{86,87}, others have demonstrated that the magnitude or direction of occlusal forces does not appear to have an effect on the stability of supporting implants and bone^{88,89}. However, Isidor⁹⁰, in an animal study, demonstrated bone loss surrounding implants subjected to extremely high off axis loading forces. Though opinion are varied, the occlusal scheme for an implant-supported restoration should be designed to decrease cuspal interferences, centralize forces along the long axis, and minimize lateral forces; in other words it should be like that of a similar restoration supported by a natural dentition⁹¹.

Patient evaluation

The patient should be thoroughly evaluated before arriving at any treatment option, after which treatment planning can commence. During the planning stages, it is important to consider the patient's expectations, medical health, financial and time constraints. Clinical examination comprises several extra and intra-oral aspects giving special attention to the alveolar bone and soft tissue contour and the possible implant reconstruction. Zitmann et al.⁹² suggested a systematic approach that addresses the following extra-oral and intra-oral parameters;

1. Correct facial proportions: Divided into 3 thirds: from hairline to eyebrow, to the subnasal point, to the chin.
2. Facial symmetry on front and in profile: parallelism among bipupilar line, smile line, occlusal plane and camper's plane;
3. Need for lip and cheek support: patients with removable prosthesis should be evaluated with and without the existing restoration in place so that a prosthesis flange for adequate support can be planned if deemed necessary;
4. Facial skeletal classification (normal, prognathic, retrognathic), need for compensation of a concave profile: check relation of the upper and lower lip to the aesthetic plane (line from the end of the nose to the chin) for "best balance of lips", which is given with equal distances or the lower lip slightly closer to this plane;
5. Intermaxillary relation: Occlusal vertical dimension (correct, reduced, increased); Interocclusal distance at rest position (correct with 2–4 mm, reduced, increased). In situations with a reduced occlusal vertical dimension, it is important to evaluate whether the interocclusal distance is increased and the OVD can be raised up to the desired dimension, or whether a muscular adaptation has occurred and interocclusal distance decreased concurrently so that a staged rise of OVD is required;

6. Incisal edge position of the maxillary centrals and occlusal plane: The position of the centrals is evaluated in rest and related to the upper lip length, as well as during smiling in relation to the height of the smile line. Patients with a high smile line generally expose the entire clinical crown with surrounding gum tissues, while with an average smile line, the central incisors are mainly visible, and with a low smile line less than 75 per cent of the incisors' length is exposed. When the alveolar ridge is displayed in patients with a high smile line, special consideration has to be given to the aesthetic aspects and the predictability of the outcome of a possible implant treatment⁹²;
7. Temporomandibular joint movement and function: TMJ pains, contraction or hypertrophy of the facial musculature occurring concurrently with abrasion and wear facets on the occlusal surfaces can be an indicator of parafunctional habits⁹².

Intra-oral examination

1. Dental examination including existing restorations and reconstructions, decayed and filled teeth, oral hygiene assessment, periodontal exam and dental pulp test; detection of malpositioned teeth (elongation, intrusion, ectopic tooth position); midline between upper central incisors corresponding to the philtrum position;
2. Occlusal status and functional examination: the diagnosis of parafunctional habits (bruxism, clenching) can be deduced from clinical findings of muscular tension and hypertrophy, dental abrasion, attrition and wear facets. Although parafunction itself is not a contraindication for implant placement it can, if uncontrolled, cause technical complications such as screw or framework fractures due to overloading. Therefore, initial therapy of temporomandibular disorders is indicated pre-surgically to reduce the eventual occlusal stresses and provide better chances of long-term success⁹³.

Site Evaluation

Number of teeth and edentulous segment. During the planning phase the number of teeth present and existing conditions should be documented. There must be adequate space between implants, and between natural teeth and implants, for proper integration and tissue health. In general, there should be 3 mm between implants and between teeth and implants⁹¹. Thus, the space needed for two implants of 4 mm diameter to be placed between natural teeth is 17 mm. Generally, the anterior mandible has adequate bone for placement of 4 to 6 implants⁹⁴. Where the mesio-distal space is more than 10 mm, a single tooth implant is not recommended.

Periodontium – oral mucosa. The mucosal quality and quantity with the underlying bone can be assessed by palpation and/or sounding. A thick keratinized mucosa is easier to mould for a papillary-like inter-implant trigonum than a thin, flappy, non-keratinized ridge tissue. Sufficient mucosal thickness helps to hide the abutment margin and better facilitates correct emergence profile of the clinical crown³⁹.

However, there are disagreements on the type of tissues that should be around implants. A 5-year longitudinal study by Schoo and van der Veldon⁹⁶ indicated that alveolar mucosa around teeth is not more likely to develop recession or inflammation than attached gingiva. Similar observations were made by Krekeler et al.⁹⁷ concerning soft tissue around implants. Clinical observations suggest that the presence or absence of attached gingiva around implants does not appear to affect long-term soft tissue health, bone loss, or implant survival rates. However, when alveolar mucosa directly surrounds the abutments, chronic trauma as a result of muscle influence in severely resorbed jaws can cause marginal irritation⁹⁸. Han et al.⁹⁹, in a case report describing a surgical technique, indicated that replacement of unattached, non-keratinized mucosa with keratinized gingiva provided attached gingiva around implants that was healthier and more resistant to inflammation. Azzi et al.¹⁰⁰ indicated that an adequate zone of attached gingiva is necessary around anterior restorations to conceal the junction between an implant and a restoration. A comparative study by Wennstrom et al.¹⁰¹, focusing on implants placed in keratinized tissues, non-keratinized tissues, and mobile soft tissues, indicated that the lack of attached masticatory mucosa around an implant did not jeopardize the maintenance of healthy soft tissues. Also because of the average bone loss of 1mm reported at 1st year post-op it is important to submerge the implant during surgery.

Periodontium - Bone support. Bone quality is often referred to as the amount (and their topographic relationship) of cortical and cancellous bone in which the recipient site is drilled. A poor bone quantity and quality have been indicated as the main risk factors for implant failure as it may be associated with excessive bone resorption and impairment in the healing process compared with higher density bone¹⁰²⁻¹⁰⁴. Clinical studies have reported dental implants in the mandible to have higher survival rates compared to those in the maxilla, especially for the posterior maxilla^{105,106}. Bone quality has been considered as the basic cause of this difference. In the posterior maxilla, there is commonly thinner cortical bone combined with thicker trabecular bone compared to the mandible¹⁰⁷⁻¹⁰⁹. Clinically, a poor degree of bone mineralization or limited bone resistance is observed in bones with poor densities, which are often referred to as “soft bones”¹⁰⁷⁻¹⁰⁹. It has been shown that achieving optimum primary stability in soft bones is difficult and is also related to a higher implant failure rate for the implants placed in such bones^{102,110}. Turkyilmaz et al.¹¹¹ reported the bone quality around the implant to be superior in the mandible compared to the maxilla. A clinical study¹¹² with 158 implant sites from 85 patients indicated a strong correlation between bone density and dental implant stability. Results by Miyamoto et al.¹¹³ demonstrated that dental implant stability is positively associated with the thickness of cortical bone thickness. In contrast to the previous studies, additional studies in the posterior mandible showed high failure rates due to the poor bone quality as well as other additional factors¹¹⁴⁻¹¹⁵.

The Lekholm and Zarb (1985)¹¹⁶ Classification (Types I-IV) is based on cortical thickness and trabecular sparseness, although not validated, is used commonly for diagnostic and surgical purposes. Type I and Type II bones are relatively

dense as they mostly consist of thick cortical bone. Type III bone is softer with more trabecular whereas Type IV bone is very soft, consisting of only a very thin layer of outer cortex with very sparse inner core of trabecular bone. The maxilla has Type III bone in the anterior and premolar regions and Type IV in the molar areas. The mandible may have Type I anteriorly and Types II and III elsewhere¹¹⁶. Studies^{112,113} have demonstrated that higher implant failures occur in softer Type IV bone. Modified surgical techniques, bone augmentation procedures and implants with certain surface design and characteristics are routinely used to improve the chance of success in case of unfavourable bone quality such as Type IV bone. Bone density and volume can be determined clinically and radiologically. The only validated method of doing so, however, is the CT or CBCT scanning³⁹. **Anatomical structures:** The major anatomical structures that needs to be taken into consideration when planning dental implant placement are the maxillary sinus, nasal floor, inferior dental nerve and mental nerve. It should be remembered that the mental nerve sometimes has an anterior loop of up to 4mm³⁹.

Investigations

a. **Radiographs:** Pre-operative radiographs are required not only to evaluate the existing bone quantity but also to identify neighboring anatomic and topographic structures which have to be preserved¹¹⁷. Important anatomic structures are the roots of the adjacent teeth, the course of the inferior alveolar nerve, the floor of the nose, the diameter of the incisal canal, and the morphology of the maxillary sinus including bony septi. Dental panoramic radiographs and periapical radiographs can be used to evaluate sites for dental implant placement. Magnification distortions are usually associated with panoramic radiographs and hence require radiopaque markers for correction of the magnification factor. They should be employed with caution when placing implants close to vital structures. Periapical radiographs may be dimensionally accurate but are limited in their ability to fully incorporate crucial anatomical structures including the inferior dental nerve and the maxillary sinus. Presently, Cone beam CT (CBCT) is the best because it gives an accurate three-dimensional image of the jaws and can be used to measure bone density however, the radiation dose is higher. Computerized tomography (CT) has been regarded as the best radiographic method for analyzing the morphological and qualitative analysis of the residual bone¹¹⁸⁻¹²⁰. It is also a valuable means for evaluating the relative distribution of cortical and cancellous bone^{39,121}.

b. **Clinical photography** showing the site and all standard views³⁹.

c. **Study casts** for planning and diagnostic wax-up³⁹.

Treatment Plan

The desired final restoration must be carefully planned and be used as a guide for the positioning of the dental implant. If this cannot be readily achieved, site development (both hard and soft tissue) and regenerative procedures should be considered to allow the correct positioning of the implants according to the restorative requirements of the final case. Treatment planning should include the recommended

treatment and other reasonable alternatives such as

No treatment

Dentures

Bridges (adhesive or conventional)

Implant treatment (and its different options)

The implantologist must make the patient to be fully aware of all possible risks and how best to manage potential complications, expected outcome of treatment and its long-term prognosis.

Once the treatment option is decided, it is important to plan the restorative and surgical phase of the treatment.

Restorative Planning

Restorative planning should include the emergence profile, aesthetic analysis and implant occlusion. The prosthesis should appear to emerge from the gingiva in a very natural way¹²¹. Clinicians should avoid “tomato on a stick” crowns because periodontal problems may develop³⁹. Aesthetic analyses should include the analysis of the smile line, which is usually high in the maxilla and low in the mandible. The shape of the lips of the patient and existing ridge defect must be taken into consideration, if visible with high smile line then the ridge will need augmentation³⁹.

Occlusal analysis

Occlusal analysis is very important in the success of an implant. It is important to have the diagnostic casts mounted on an articulator. Studies^{86,87} have shown less implant success in patients with parafunctional habits and patients who had tooth loss due to occlusal trauma.

In summary, the basic guidelines to implant occlusion are³⁹:

1. Provide even bilateral contacts in centric position.
2. Prepare the mutually protective occlusion, if possible.
3. Reduce the occlusal contacts in cantilever area.
4. Avoid or reduce the occlusal contacts in excursive movements.

Surgical Planning

Surgical planning follows on directly from restorative planning which starts with a diagnostic wax-up to determine the ideal restorative position. This will allow the practitioner to see where implants should be placed in order to support the planned prosthesis optimally³⁹.

Choice of implant length/diameter

Among the implant designs, implant diameter and length have been intensively studied and well accepted as key factors, since they directly influence the primary stability, placement, and removal torque values of dental implant¹²². The length of implant fixture to be used is determined by quantity of bone apical to extraction site or anatomical structures. It is advisable to use the longest implant safely possible. Also the diameter is dictated by corresponding root anatomy at crest of bone. Horiuchi et al.¹²³ suggested that implants should be at least 10 mm long to ensure a high success rate. Chiapasco et al.¹²⁴ proposed that it would be better to use implants more than 14 mm in length and more than 4 mm in diameter. However, a review of the literature suggested that when adequate surgical preparation is made and indications for implant treatment duly considered, the survival rates for short and for wide-diameter implants are

comparable with those obtained with longer implants and those of a standard diameter¹²⁵.

Treatment

An implant can be placed either in a fresh extraction socket at the time of tooth removal (immediate) or later in native alveolar bone (delayed). Although many classifications exist but for the purpose of this review, it will be limited to immediate, delayed immediate and delayed.

Immediate Implant

This involves placement of dental implants directly into a fresh extraction socket¹²⁶. The advantages of such option are numerous to the patients and the clinician but, it requires expertise and experience. The advantages are that post extraction healing and osseointegration occur simultaneously, surgical procedure and time are minimized and it is cost effective on the long run¹²⁶. However, some disadvantages of such procedure include difficulty in obtaining primary implant stability, need for additional procedures like grafting to fill up the space between implants and the bone, presence of residual infection which may lead to peri-implantitis¹²⁶.

Delayed Immediate and Delayed Implant

Delayed immediate (usually about 8-10 weeks) and delayed placements (usually about 9-10 months or longer) have the disadvantage that the treatment is more protracted compared with immediate placement^{39,127}. However, delaying the implantation allows for soft tissue coverage over the socket, which in return makes primary wound closure and graft containment easier. Deferral of implant placement also allows any pre-existing area of infection to subside. Late placement means overall treatment time is longer, however when preparing recipient sites in healed bone, the osteotomy may be positioned optimally³⁹. Delayed placement is usually the treatment option for multi-rooted sites thus allowing the implant to be placed centrally in the available space. Late placement is also indicated when the tooth has been chronically infected or the socket requires substantial regeneration using the Guided Bone Regeneration or socket augmentation techniques³⁹.

Surgical procedure

Dental implantology is a restoratively guided discipline with a significant oral surgical component. It should be meticulously planned and executed to ensure the highest probability of success both functionally and aesthetically with minimum morbidity and discomfort for the patient and the minimum risk of damage to vital structures. Successful implant surgery should follow the sound principles of oral surgery. Hence there is need for proper planning before undertaking the procedure.

In preparation for implant surgery, oral and dental diseases should be treated. In addition, provision of surgical stent is critical for achieving an ideal surgical aesthetic result. It is used during fixture installation as guide for optimal buccolingual and mesio-distal positioning.

Also, oral prophylaxis such as scaling and polishing and oral hygiene instruction should be done. Preoperative medication

should be given in good time to be effective. Non-steroidal anti-inflammatory drugs and antimicrobials work best as preventive drugs and should be administered with sufficient time for them to be absorbed before surgery commences³⁹.

Aseptic Surgical Technique: cross infection control is critical not only to prevent cross contamination but also to reduce the bacterial count within the surgical field. This would normally involve the use of full sterile set of surgical drapes and gowns for the operating team and the patient. Preoperative use of mouthwashes and skin disinfection are considered good practice. Sterilization and safe storage of large number of surgical instruments that may be needed for each case should conform to current policies and guidelines. **Pain and Anxiety Control:** Implant surgery can be prolonged. The administration of appropriate type and dosage of local anesthesia is crucial to ensure that the surgical field is anaesthetized adequately for the duration of the operation without overdosing.

Advanced implant surgery may include regenerative procedures such as guided bone regeneration (GBR), bone condensation, ridge splitting (Figs.1a-1c), particulate grafting, autogenous block grafting, sinus augmentation, connective tissue grafting and further special methods such as inferior dental nerve repositioning and distraction osteogenesis.

Proper surgical technique during implant placement is critical; there should be minimal heat generation during preparation of the implant well. Ideally less than 47° Celsius for one minute or less provides the most predictable healing response³⁹.

Surgical Phase

The original Branemark protocol required a vestibular flap with a two stage approach. The implant is placed and buried under the soft tissue and after an adequate period of healing (three months mandible, six months maxilla) (Fig 1c),

Stage I - implant fixture placement with cover screw (submerged)

Stage I - healing phase

3 months minimum (mandible) - usually 6 months for posterior regions

6 months minimum (maxilla) - usually 6-9 months for all regions

Stage II - Uncovering and placement of healing abutment (Fig. 2a). A second stage surgery is performed with crestal incisions to expose the fixtures and connect a trans-epithelial abutment (healing abutment). During this stage the mucosa over the implant is incised and the implant head located. The cover screw is unscrewed and healing abutment placed.

Healing abutment is a cylindrical component that is screwed into the implant and may be used at first stage surgery, or more commonly at second stage surgery (Fig. 2a). It extends through the gingival tissues to help contour the tissues (Healing phase: 4 - 6 weeks for soft tissue healing) to receive the final restoration (Fig. 2b).

One stage surgical protocol was developed by ITI in Switzerland¹²⁸. It requires a crestal incision or a flapless approach, drilling directly through the soft tissues. It also allowed the implant fixture to extend through the soft tissues during the period of initial healing. One stage is suitable in cases with adequate bone width with sufficient keratinized soft tissue.

Restorative phase

The restorative phase of treatment such as fabrication of surgical guides starts before the implants are placed. Also provisional restorations that maintain appearance and function during implant treatment are also fabricated during this phase.

Provisional restorations

Before starting implant treatment a provisional or transitional restoration should be made that will be durable throughout what can sometimes be a lengthy course of treatment. The requirements of a provisional restoration are that it should allow for the implant sites to be minimally loaded immediately after initial surgery. They should also be designed so that they are easily adapted following placement of healing abutments and subsequent implant restorative procedures.

Abutment selection

Abutments are components that attach to the implant head and are retained to the implant by an abutment screw that extends through the abutment into the body of the implant. The abutment extends through the gingiva into the oral cavity and it provides the support for the restoration. It could be straight or angled to overcome severe alignment problems between implants.

The healing abutment is unscrewed and the height of soft tissue from the rim of the implant head to the gingival margin measured with a periodontal probe. If possible and where necessary, the abutment is selected so that the margin for the restoration is placed 1–2 mm subgingivally.

Seating the abutment

Once the appropriate abutment has been selected it is then seated onto the implant head. It is essential that full seating is ensured and as the abutment-implant junction is commonly



Fig. 1a: Preparation of implant well with surgical drills after ridge split



Fig. 1b: Two regular size implants in splitted bone with cover screws

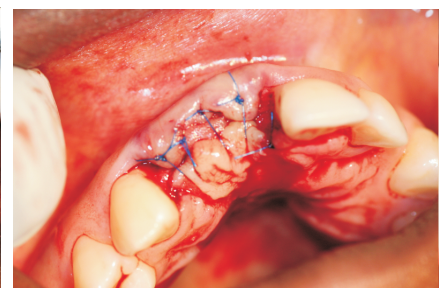


Fig. 1c: Site sutured



Fig. 2a Showing healing abutment in place

subgingival, checking with an intra-oral radiograph may be needed. When full seating has been verified, the abutment screw can be tightened to the manufacturer's recommended level of force using a torque wrench.

Impression taking

The aim of an impression for implant restorations is to record the implant positions in a master working cast. There are two types of implant impression coping: pick-up and transfer copings.

Laboratory techniques

Many of the laboratory techniques for implant restorations are essentially the same as for conventional prosthodontic treatment. Working casts are made using precise replicas of the abutments and machine-made gold cylinders that fit the abutments accurately can be incorporated into conventional framework wax-ups and then cast in a suitable precious gold alloy. Casts are normally made with a flexible silicone rubber gingival cuff, which is removable from the cast, allowing the dental technician to make sure that there is an accurate fit of the abutment/restoration in the subgingival region and to help visualize and create emergence crown contours and profiles that are consistent with the gingival margin.

Restoration insertion

If all other procedures have been performed correctly the fit appointment should be reasonably straightforward. The occlusion and appearance need to be checked and the patient given appropriate oral hygiene instruction. The bridge screws can then be progressively tightened in sequence in an order that will not produce stress within the bridge.

Occlusion

For single tooth restorations or limited span bridges, occlusal contacts need to be examined in light and heavy contact. It should be remembered that the implant is in effect ankylosed and so will not move under occlusal contact when compared with a tooth. Therefore the implant restoration should be in enough contact to lightly mark occlusal indicator paper but should not hold shim stock. It is important that the restoration is not totally out of occlusion because the risk is that there may be uncontrolled overeruption of the opposing teeth resulting in a loss of occlusal stability and occlusal interferences.

Maintenance Phase

The following parameters are important the maintenance phase,

1. Home-care regimen: This involves reinforcement of oral hygiene instructions. Patients should be advised to use super-floss or interdental brushes for interproximal cleaning of prosthesis and abutment surfaces. Metal tip should never be used during professional scaling and polishing³⁹.
2. Periodic recalls reinforcing regimen: Recall visits should be scheduled for immediate post-delivery, 24 hours, one week, two weeks (re-torque if needed), 6 months bi-annual or annual evaluation and there should be strict adherence to recall schedule³⁹.

During the recall visits the following clinical parameters should be evaluated.

- 1 Oral hygiene including plaque index: Plaque is primary etiologic factor in tissue destruction (peri-implant and natural tooth) so it is important to review oral hygiene instructions by monitoring through plaque indices.
2. Implant stability: Implant stability (evaluate mobility) may be the key indicator of fixture health. Minimal mobility of around 17 - 57 μ m buccal and 17 - 66 μ m lingual is compatible with implant health.
3. Peri-implant tissue health: Visual inspection should be done or signs of pathoses such as alterations in color, contour and consistency of alveolar mucosa.
4. Crevicular probing depths is the most accurate means of detecting peri-implant tissue destruction (use plastic probes). Probing measurements closely approximate actual bone levels. However, probing should be avoided during first 3 months after abutment connection to avoid damaging weak epithelial attachment.
5. Bleeding: There is controversy as to the significance of bleeding on gentle probing at peri-implant interface. BOP may precede clinical signs of inflammation. BOP and radiographic changes are most valid indicators of peri-implant breakdown. It is recommended that continued use of peri-implant sulcus probing be done to



Figure 3b: Gingival cuff created by the healing abutment

monitor implant success.

6. Radiographic assessment (serial): Serial radiographic assessment is one of the most valuable ways to monitor implant success and it could help to accurately determine amount of bone loss. Bone levels are compared with stable landmarks such as implant threads. It should be noted however, that about 1.0mm marginal bone loss is expected during first year post insertion and thereafter about 0.1mm per year should be anticipated. Greater bone loss is also usually observed in maxilla. Rapid bone loss is seen if there is fractured fixture, initial osseous trauma at insertion, fixture over-tightening, occlusal trauma, poor adaptation of prosthesis to abutment, plaque-associated infection (peri-implantitis)³⁹.

7. Proper torque on screw joints: Loose screws can cause localized inflammation, loose restorations, and discomfort. However, it should be noted that excessive force can fracture screw/implant or create increased stresses in the bone³⁹.

8. Occlusion: Excessive force concentrations can result in extensive bone loss and implant fracture. Major causes include poor abutment prosthesis adaptation, poor force distribution and improperly planned occlusal schemes. Therefore the best occlusal scheme should be balanced occlusion and it is important to have "light centric" occlusion only. There should be no contact in lateral excursions³⁹.

Problems of implant treatments:

1. Soft tissue reactions - This occur commonly due to loose screws and poor oral hygiene which can lead to "peri-implantitis" and may progress to gradual bone loss and subsequent lack of attached peri-abutment soft tissue³⁹.

2. Fractured or loosened screws -This can occur when using wrong screwdriver or excessive force. Also excess force can "round off" the hex hence making it difficult for the screwdriver to engage the hex. Screws can be retrieved by gently teasing out fractured screw with caution not to damage the hex. Screws removing kits are generally sold with implant kit and are very useful in the removal of fractured screws³⁹.

3. Failing/failed implant - These conditions are characterized by progressive crestal bone loss, soft tissue pocketing, bleeding on gentle probing with possible pus and tenderness to percussion or torque. Causes of failing implant include: Overheating of bone, lack of initial stability, too rapid initial loading, functional overload, inadequate screw joint closure and infection. Management of this condition should first be symptomatic i.e treat infection and re-evaluate the condition. In the interim it is advisable to remove the prosthesis and abutments followed by copious irrigation of the area with chlorhexidine, implant components should also be disinfected before being replaced. However if symptoms persist, it is advisable to remove the implant and replace with larger diameter fixture³⁹.

Clinical signs of failed implants includes: mobility; "dull" percussion sound; peri-implant radiolucency (connective tissue implant encapsulation may not be visible on radiograph).

Broken attachments/ components: The treatment is to

remove offending attachment (if possible) and replace but care must be taken not to scratch titanium fixture or abutment³⁹.

Criteria for success:

- no peri-implantitis
- no associated radiographic radiolucency
- marginal bone loss 1.0-1.5mm first year; then < 0.1mm annually thereafter
- tissue integration: bone/soft tissue "osseointegration"
- absence of mobility
- no progressive soft tissue changes or bone loss
- stable clinical attachment level
- absence of bleeding upon probing/excessive probing depths
- absence of discomfort

Conclusion

The success rate of implant varies with bone quality, loading dynamics, and maintenance. The anticipated 10-year success rate is about 97% in anterior mandible, 90% in anterior maxilla and decreases in posterior quadrants due to poorer bone.

More importantly, careful patient selection, proper treatment planning, proper surgical procedure, careful restorative planning and consistent maintenance phase will guarantee long survival rates of dental implant.

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