Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 1(A), pp. 22898-22907, January, 2018

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Review Article

BIOLOGICAL CONSIDERATIONS OF DENTAL IMPLANTS: A LITERATURE REVIEW

Amit Daityari*., Archana Singh., Dnyaneshwari Gujar., Dharmarajan Gopalakrishnan and Santosh Martande

Department of Periodontology, Dr. D. Y. Patil Dental College and Hospital, Dr. D Y Patil Vidyapeeth Pimpri, Pune, Maharashtra, India

DOI: http://dx.doi.org/10.24327/ijrsr.2018.0901.1358

ARTICLE INFO

Article History:

Received 20th October, 2017
Received in revised form 29th November, 2017
Accepted 30th December, 2017
Published online 28th January, 2018

Key Words:

Dental Implants, Biologic Width, Available Bone, Implant supported Prosthesis

ABSTRACT

Today's arsenal of therapeutics makes the choice of best treatment strategy for the individual patient very sophisticated. As dental implants have become more predictable, the clinician is often confronted with the dilemma whether to use implants or other modalities. The survival and success rates reported by many implant investigators often exceed the success rates of some forms traditional dental treatment. In particular, it could be argued that implant – borne prosthesis have a better outcome than apical surgery, conventional endodontic re – treatment and conventional dentures.

The natural tooth must not be considered as an obstacle but a possibility, whether or not the treatment is to include implant installation. "Many roads lead to Rome" and that the dental team has a delicate palette of treatment options to consider, not least regarding the use of natural teeth vs implants in various prosthetic treatment plans.

INTRODUCTION

Tooth loss is also followed by resorption of the alveolar bone, which exacerbates the resultant tissue deficit.[1] Implants have been used to support dental prostheses for many decades but they have not always enjoyed a favourable reputation. This situation has changed dramatically with the development of endosseous osseointegrated dental implants. They are the nearest equivalent replacement to the natural tooth, and are therefore a useful addition in the management of patients who have missing teeth because of disease, trauma or developmental anomalies.

Clinicians have long sought to provide their patients with an artificial analogue of the natural teeth and a wide variety of materials and techniques have been used for this. However, it has not been possible to replicate the periodontal tissues and alternative strategies have therefore been adapted. These have been based on the principles of creating and maintaining an interface between the implant and the surrounding bone, which is capable of load transmission associated with healthy adjacent tissues, predictable in outcome and with a high success rate. This outcome proved elusive until the discovery of the phenomenon of osseointegration.[2]

Rationale for Dental Implants

The clinical replacement of lost natural teeth by osseointegrated implants has represented one of the most significant advances in restorative dentistry. Two decades ago, a majority of dentists were sceptical about implants and rejected them entirely. [3]

Implant therapy offers many advantages over conventional fixed or removable treatment options and in many cases is the treatment of choice. However, many clinicians still do not use implant therapy and choose instead to prepare teeth for fixed partial dentures.

To obtain optimal aesthetic results with fixed partial dentures, a significant reduction in the amount of tooth structure is necessary occasionally predisposing to endodontic, periodontal and structural sequelae.[4]

Anatomic Problems and Consequences of Edentulism

1. Decreased width of supporting bone.
2. Decreased height of supporting bone.
3. Decrease in keratinized mucosa.
4. Prominent mylohyoid and internal oblique ridges.
5. Prominent superior genial tubercles.

Corresponding author:* **Amit Daityari
Department of Periodontology, Dr. D. Y. Patil Dental College and Hospital, Dr. D Y Patil Vidyapeeth Pimpri, Pune, Maharashtra, India

6. Elevation of prosthesis with contraction of mylohyoid and buccinator muscles serving as posterior support.
7. Mucosal thinning with sensitivity to abrasion.
8. Loss of basal bone.
9. Paresthesia from dehiscent mandibular canal.
10. Increase in tongue size.
11. Increase in activity of tongue in mastication.
12. Effect of bone loss on esthetic appearance of lower 1/3 of face.

Along with the loss of teeth, the facial changes normally occurred and associated with process of aging, can be accelerated. There would be decrease in facial height from a collapsed vertical dimension, and several other related facial changes would also occur. As the vertical dimension goes on decreasing, the occlusion evolves towards a pseudo Class III malocclusion. Here, development of prognathic facial appearance occurs.

The esthetic consequences of edentulism can be summarized as follows:

1. Prognathic appearance.
2. Decrease in horizontal labial angle.
3. Thinning of the lips, especially the maxilla.
4. Deepening of nasolabial groove.
5. Increased depth of associated vertical lines.
6. Decreased facial height.
7. Ptosis of muscles (-jowls‖ and/or-witch‘s chin‖)
8. Loss of tone in muscles of facial expression.
9. Increased length of upper lip and thinning of upper lip due to poor lip support provided by the prosthesis.
10. -Aged smile‖ appearance due to lower high lip-line position and less teeth shown at rest position.

Decreased Performance of Removable Prosthesis

The difference in maximum occlusal forces recorded in a person with natural teeth and one who is completely edentulous is dramatic. The maximum occlusal force in the edentulous patient is reduced to less than 50 psi. The patient wearing complete dentures for more than 15 years may have a maximum occlusal force of 5.6 psi. Hence due to the decreased occlusal force and instability of the denture, masticatory efficiency also decreases with tooth loss. Also the reduced intake of high fiber food and poor swallowing could induce gastrointestinal problems in edentulous patients. The deficient masticatory efficiency in a person can lead to illness, debilitation and shortened life expectancy.

Why are Implants preferred over Dentures and Bridges?

Dentures are generally loose and unstable. There are chances of falling out while talking and eating, and inability to pronounce properly, whereas implants can provide stable dental replacements both functional and aesthetic. Dentures and bridges require the grinding of adjacent healthy teeth on either side to support the bridge. When these teeth are lost at a later stage, the entire bridge needs replacement and grinding of the other teeth for new bridge. Implants are directly attached to the bone and gums, so no support of neighboring teeth are spared of long-term problems.

Chewing efficiency of removable partial and complete dentures is only 20-25% of natural teeth, but for implanted teeth it can be 90-95%. [5]

Advantages of Implant-supported Prosthesis

Following are the advantages of Implant-supported prostheses

1. Maintenance of esthetics.
2. Maintenance of bone.
3. Maintenance of occlusal vertical dimension.
4. Proper occlusion.
5. Improved psychological health.
6. Tooth positioned for esthetics.
7. Regained proprioception.
8. Maintenance of muscles of mastication and facial expression.
9. Improved phonetics.
10. Increased retention.
11. Increased stability.
12. Improved success rate of prosthesis.
13. Improved prosthesis function.
14. Increased survival time of restoration.

Biological Considerations Related To Dental Implants

Soft Tissue Involved in Placement of Dental Implants Gingiva

Dentogingival Junction

The dentogingival junction, or area where the soft oral tissues join the hard dental tissues, protects the root of the tooth, periodontal ligament, and alveolar bone against chemical and bacterial invasion. It consist of two elements: a dense resilient connective tissue, the lamina propria, and a thick, mostly parakeratinized or keratinized epithelium. (The lamina propria provides a firm attachment for the tooth and encircle it. Its function is to resist the mechanical forces of mastication. The epithelium encircles the tooth like a collar or mucopolysaccharides).[6]

The epithelium, which is called either the epithelial attachment or the attached epithelial cuff, seals the dentogingival junction, preventing the invasion of bacteria, their toxins, and the products of food decay.

The dentogingival junction is formed as the tooth erupts, and its location on the tooth‘s surface depends upon the tooth‘s stage of eruption. Before the tooth erupts, its entire enamel surface down to the cementoenamel junction is covered with a thin membrane, called the reduced dental epithelium, which is organically attached to the enamel.[7]

The Mucosa at Teeth and Implants

Biologic Width

A term frequently used to describe the dimensions of the soft tissues that face the teeth is the biologic width of the soft tissue attachment.

The development of the biologic width concept was based on studies and analyses by, Gottlieb (1921), Orban and Kohler (1924), and Sicher (1959), who documented that the soft tissue attached to the teeth was comprised of two parts.

1. Fibrous tissue.
2. Attachment of epithelium.

In a publication by Gargiulo *et al.* (1961)[8] called -Dimensions and relations of the dentogingival junction in humans‖, sections from autopsy block specimens that exhibited different degree of -passive tooth eruption were examined. Histometric assessments were made to describe the length of the sulcus (not part of the attachment), the epithelial attachment (today called junctional epithelium), and of the connective tissue attachment. It was observed that the length of the connective tissue attachment varied within narrow limits (1.06-1.08 mm) while the length of the attached epithelium was about 1.4 mm at sites with normal periodontium, 0.8 mm at sites with moderate and 0.7 mm at sites with advanced periodontal tissue breakdown. In other words,

1. The biologic width of the attachment varied between about 2.5 mm in the normal case and 1.8 mm in the advanced disease case, and
2. The most variable part of the attachment was the length of the epithelial attachment (junctional epithelium).

Dimensions of the Buccal Tissue

The morphologic characteristics of the gingiva are related to the dimension of the alveolar process, the form (anatomy) of the teeth, events that occur during tooth eruption, and the eventual inclination and position of the fully erupted teeth (Wheeler 1961; O'Connor & Biggs 1964; Weisgold 1977) proposed that,

1. The anatomy of the gingiva is related to the contour of the osseous crest[9],
2. Two basic types of gingival architecture may exist, namely the -pronounced scalloped and the -flat biotype.[10]

Subjects who belong to the -pronounced scalloped biotype have long and slender teeth with tapered crown form, delicate cervical convexity and minuteinterdental contact areas that are located close to the incisal edge. The maxillary front teeth of such individuals are surrounded with a thin free gingival, the buccal margin of which is located at or apical of the cement-enamel junction. The zone of gingival is narrow, and the outline of the gingival margin is highly scalloped (Olsson *et al.* 1993***).***[10] On the other hand, subjects who belong to the ―flat gingival biotype have incisors with squared crown form with pronounced cervical convexity. The gingiva of such individuals is wider and more voluminous, the contact areas between the teeth are large and more apically located, and the interdental papillae are short. It was reported that subjects with pronounced scalloped gingiva often exhibited more advanced soft tissue recession in the anterior maxilla than subjects with a flat gingiva (Olsson & Lindhe 1991).

The dimensions of the buccal gingiva may also be affected by the bucco-lingual position of the tooth within the alveolar process. A change of the tooth position in buccal direction results in reduced dimensions of the buccal gingival, while an increase is observed following a lingual tooth movement (Andlin-Sobocki & Brodin 1993).[11] In fact, Muller and Kononen (2005) demonstrated in a study of the variability of the thickness of the buccal gingiva of young adults that most of the variation in gingival thickness was due to the tooth position and that the contribution of subject variability (i.e. flat and pronounced scalloped) was minimal.

Dimensions of the Interdental Papilla

The interdental papilla in a normal, healthy dentition has one buccal and one lingual/palatal component that are joined in the col region. Experiments performed in the 1960s (Kohl & Zander 1961; Matherson & Zander 1963) revealed that the shape of the papilla in col region was not determined by the outline of the bone crest but by the shape of the contact relationship that existed between adjacent teeth.[10]

Tarnow *et al.* (1992)[13] studied whether the distance between the contact point (area) between teeth and the crest of the corresponding inter proximal bone could influence the degree of papilla fill that occurred at the site. Presence or absence of a papilla was determined visually in periodontally healthy subjects. If there was no space visible apical of the contact point, the papilla was considered complete. If a ―black space was visible at the site, the papilla was considered incomplete. The distance between the facial level of the contact point and the bone crest was measured by sounding. The measurement thus included not only the epithelium and connective tissue of the papilla but in addition the entire supralveolar connective tissue in the inter proximal area. The authors reported that the papilla was always complete when the distance from the contact point to the crest of the bone was ≤ 5mm. When this distance was 6 mm, papilla fill occurred in about 50% of cases and at sites where the distance was ≥ 7 mm, the papilla fill was incomplete in about 75% of cases. Considering that the supracrestal connective tissue attachment is about 1 mm high, the above data indicate that the papilla height may be limited to about 4 mm in most cases. Interestingly, papillae of similar height (3.2-4.3 mm) were found to reform following surgical denudation procedures (van der Velden 1982; Pontoriero & Carnevale 2001), but to a greater height in patients with a thick (flat) than in those with a thin (pronounced scalloped) biotype[14].

So summarize,

Flat gingival (periodontal) biotype

The buccal marginal gingival is comparatively thick, the papillae are often short, the bone of the buccal cortical wall is thick, and the vertical distance between the interdental bone crest and the buccal bone is short (about 2 mm).

Pronounced scalloped gingival (periodontal) biotype

The buccal marginal gingiva is delicate and may often be located apical to the cement-enamel junction (receded), the papillae are high and slender, the buccal bone wall is often thin and the vertical distance between the interdental bone crest and the buccal bone is long (> 4 mm).

The Peri-Implant Mucosa

The soft tissue that surrounds dental implants is termed peri-implant mucosa. Features of the peri-implant mucosa are established during the process of wound healing that occurs subsequent to the closure of mucoperiosteal flaps following implant installation (one-stage procedure) or following abutment connection (two-stage procedure) surgery. Healing of the mucosa results in the establishment of a soft tissue attachment (transmucosal attachment) to the implant. This attachment serves as a seal that prevents products from the oral cavity reaching the bone tissue, and thus ensures osseointegration and the rigid fixation of the implant.[10]

The peri-implant mucosa and the gingiva have several clinical and histological characteristics in common. Some important differences, however, also exist between the gingiva and the peri-implant mucosa.

Bone must respond in several ways to successfully support an implant. Because most endosteal implants are placed in edentulous areas, the bone must initially be trephined, or drilled, to provide a receptor site for the implant. It must respond to osteotomy in a positive manner to allow appropriate bone healing to occur. Recent studies have indicated that use of slow speed rotary cutting instruments with internal irrigation provides the least amount of cell damage to bone during the cutting procedure. However, this finding is disputed by others who claim that standard dental rotary cutting procedures with copious externally applied irrigation are just as successful in the healing of bone. There is agreement, however, that there must be minimum elevation of bone temperature during cutting. Following the osteotomy, the bone then must heal around the endosteal implant surface.

With the attachment of a prosthetic device, the bone next experiences the effects from loading the implant. In the case of a one stage endosteal implant these forces may be applied at any time. Some protocols delay this event until approximately 8 to 12 weeks after insertion of the implant, whereas others follow a schedule similar to two stage devices.

With the two stage devices, the prosthetic loading procedures are usually instituted 4 to 6 months after initial insertion of the implant. When the prosthetic load is placed on the implant, the load is transferred to the bone. Some studies have shown that this load transfer may initiate bone resorption. When threaded implants are used, stress is concentrated around the thread tips, and there is growing evidence that bone in this area may display active resorption with the development of a highly cellular fibrous stroma that contains no calcified tissue. This may indicate that all the recently healed bone has been reabsorbed under the pressure of the prosthetic device and has been replaced with an active fibrocellular connective tissue. Beginning ossification in this fibrocellularstroma has even been observed, which further indicates that activity in this fibrocellular tissue can restore new calcified tissue in approximately 5 to 6 months.

Following healing and restoration of a bone interface, the bone must now be maintained in a healthy state to provide continued long term support for the implant and prosthesis. Maintenance of healthy bone is predicated on maintenance of good oral health and retention of the established of good oral health and retention of the established biologic seal. The stages of critical bone turnover and healing parameters are summarized as follows:

1. Initial surgery, preparation of osteotomy.
2. Bone healing; cellular response and reestablishment of bone-to-implant interface following surgery.
3. Mature bone interface following completion of healing and remodeling of repair bone.
4. Prosthetic loading; bone subjected to occlusal forces.
5. Bone reabsorption around implant in response to loading; bone replaced with fibrocellularstroma.
6. Ossification begins in fibrocellularstroma.
7. Ossification complete; commencement of remodeling in repair bone.
8. Mature bone once again interfaces the implant.
9. Maintenance of bone in a healthy state by oral hygiene, disease control and avoidance of occlusal disharmonies.

Bone response to the subperiosteal implant is slightly different. In this procedure, the bone is not subjected to an osteotomy that may produce heat and damage the bone cells. However, the elevation of an extensive full thickness flap results in the stripping off of the attached gingiva with lamina propria and underlying periosteal covering from the bone. This temporarily separates the tissues that provide the nutrient supply to the osteoblastic cells and the outer surface of the cortical bone. This surgical technique may disrupt enough nutrient blood supply to allow necrosis of bone osteocytes to occur. With the death of these cells, focal areas of bone could become nonvital and be eventually reabsorbed by phagocytic cellular activity that is constantly occurring. Thus in the absence of functional stress stimulation, discrepancies in the adaptation of the subperiosteal substructure to bone could occur and with the passage of time could be attributed to this bone reaction phenomena. The osteoblasts lining the endosteal surfaces of the jaw bone usually become quite active in response to the surgical manipulation of the periosteum and respond by initial osteoclastic activity followed by deposition of new bone on the interior surface of the lamellar and cortical bone.[15]

Thus the thickness and quantity of the alveolar process may remain approximately stable. From this it may be speculated that the repositioning of bone from outer cortical plate to inner bone endosteal surfaces could leave a subperiosteal framework ill fitting. However, superimposition of functional stress on the bone as a result of the placement of the implant could counteract bone loss subjacent to the periosteum.[16] As with any implant, the goal is to restore function to the supporting bone and thus ensure its preservation through the normal remodeling process. The well-established, long-term favourable history of the complete mandibular subperiosteal implant would indicate its frequent meeting of that goal. Current speculation regarding the reaction of the jaw bone to subperiosteal implant placement is summarized as follows:

1. The dissection of the subperiosteum from the bone during implant surgery disrupts the blood supply to the outer cortical bone. The two-stage surgical impression procedure for standard subperiosteal implants disrupts this blood supply twice.
2. The surgical disruption of the outer periosteum stimulates osteoblastic activity of the bone cells lining the internal endosteal layers.
3. The disruption of the periosteum and the stimulation of osteoblastic and osteoclastic acitivty following implant surgery result in remodeling of the outer cortical alveolar bone under the subperiosteal implant.
4. This remodeling phenomenon may give rise to some of the irregularities in terms of framework fit that occur later in the subperiosteal implant function.

5. The alveolar bone will respond to adverse occlusal forces with potential resorption or remodeling of bone during the service period of the implant.

In recent years, the actual distribution of stress in the bone surrounding dental implants has received considerable interest. Studies in this area have relied on photoelastic stress analysis and finite element analysis and seem to be consistent in showing the locations of stress concentrations.[17]

Hard Tissue Involved In Placement of Dental Implants

Before attempting any kind of endosseous or subperiosteal implant procedure it is necessary to have a thorough knowledge of the tissues involved. The normal structure and function of the tissues, the physical and chemical factors affecting their health, and their responses to trauma and other stimuli must be Understood.[18]

The brief review of the anatomy of the mandible and maxillae is necessary so that those structures can be avoided in an implant intervention. The most important landmarks are the mandibular canal and mental foramen and the relative position of the maxillary sinus and nasal vestibulum. These will be discussed and illustrated extensively, as they are prime factors in planning implant procedures.

Mandible

The mandible, or lower jaw, is a horseshoe shaped body bearing at each end a flattened upward extension called the ramus (**Fig.3**) The upper end of each ramus has two processes, an anterior coronoid process and a posterior condylar process. These articulate with the bones of the upper face, permitting movement of the mandible against the skull.[19]

At birth the right and left halves of the mandible are joined only by fibrous tissue. During the second year of life, the halves fuse at the mental symphysis. Along the line of the symphysis, on the outer surface, is a triangular shaped mental protuberance. The lower angles of this protuberance from a mental tubercle on each side. This entire area, popularly called the chin, is an area of relatively thick bone.[19]

The thickness extends back along the lower border of the mandible, passing slightly upward to become continuous with the anterior border of the ramus. The thickened areas serve as attachment sites for the muscles.

Mandibular Canal (Inferior Dental Canal)

Of prime importance in the mandible is the pathway of the mandibular branch of the trigeminal nerve and its accompanying vessels. The trigeminal, or fifth cranial, nerve is mainly responsible for the cutaneous supply of the face and scalp. In addition, it provides motor innervations for the muscles of mastication. The major portion is sensory and gives rise to three divisions: opthalmic, maxillary, and mandibular. In the lower part of the face on each side, a branch of the trigeminal nerve passes between the processes of the ramus and into the mandible on its inner surface via the mandibular foramen, which is marked by a spur of bone called the lingual.[20]

The major mandibular feature to be avoided during implant surgery or insertion is the mandibular canal, also called the inferior dental or inferior alveolar canal. This is a large, distinct channel in bone that runs through the ramus and body of the mandible from the mandibular foramen on the medial surface of the ramus to the mental foramen on the lateral surface of the body, usually in the premolar area.

The mandibular canal contains the mandibular (inferior dental or alveolar) nerve, which supplies the bone and teeth up to the bicuspid region, where itbifurcates. The major portion of the nerve exits the mandibular body through the mental foramen and passes into and supplies the soft tissues of the chin and lower lip. The smaller portion continues anteriorly within bone in the incisive canal toward the inferior aspect of the incisors.

The Mental Foramen

The mental foramen is the opening through which the mental canal releases its neurovascular bundle into the soft tissues to supply the lower lip and chin. The mental canal arises from the mandibular, or inferior alveolar, canal where it bifurcates in the bicuspid region. The mental canal is usually the greater of the two branches. The other branches, the inferior incisal canal, continues anteriorly and inferiorly toward the midline within bone as a much less significant anatomical feature. Often by the incisor region the inferior incisal canal is indistinguishable radiographically. Sometimes, however, the incisal canal is as large as the mandibular canal for a very short distance after the bifurcation. This may be confusing radiographically, if the mental canal is not clearly depicted so that the bifurcation of the mandibular canal into two branches is obvious. Even if the inferior incisal canal does appear fat after the bifurcation, it rapidly tapers into the more typically thin size. Also it should be noted that after bifurcation, the branches diverge, with the incisal canal directed inferiorly.[21]

As the mental canal arises from the mandibular canal, it turns outward and slightly backward, terminating as the mental foramen at varying distances from the mandibular canal and from the alveolar crest. When teeth are present, the most common site for the foramen is at or immediately below the apex of the second bicuspid. However, in relation to the second bicuspid – a more common reference point – the foramen may appear mesial or distal to the root, and range in height on the mandibular body from well below the apex of the root to almost halfway up the root. Sometimes the foramen lies closer to the first bicuspid, then to the second, again with its height at varying levels.

The foramen is higher than the mandibular canal, and it usually appears so radiographically. However, the distance of the mental foramen from the mandibular canal is difficult to determine from radiographs. It varies considerably depending upon the prices location of the foramen and the depth of the mandibular canal within the mandibular body. Thus the length of the mental canal may range from a few millimeters to over one centimeter. The further the mandibular canal is from the labial surface of the mandible and the higher and more posterior the mental foramen is to the bifurcation, the longer the mental canal will be. And vice versa. Also, the mental canal itself may be indistinct radiographically because the shadow of the foramen is superimposed.[22]

When the site or jaw is edentulous, the alveolar crest becomes the most important reference point, particularly when implants are contemplated. Normally when the crest is high, the foramen is slightly below an imaginary horizontal midline of the mandibular body. When the teeth are lost, ridge resorption moves the crest down toward the foramen. Extensive resorption may place the foramen at the crest, with the mental canal, depending upon its course dehiscent. If the mental canal rises only slightly superiorly from the mandibular canal, its contents and perhaps those of the mandibular canal may be exposed. If the canal drops sharply down towards a deep mandibular canal, only that superior portion near the foramen may be affected.

Maxillary Sinus

The upper jaw is formed by paired maxillae joined in the midline and strongly fused to the skull along their outer borders. Each maxilla consist of a pyramidal hollow body and four processes: zygomatic, frontal, alveolar and palatine. Together they form the greater part of the skeleton of the upper face.

The zygomatic process, which projects laterally between the anterior and posterior surfaces, supports the zygomatic bone. The frontal process projects upfrom the upper anterior portion of the body, forming the inner margin of the orbit and part of the lateral wall of the nose. The alveolar process containing the sockets for the teeth of the upper jaw projects down from the inferior part of the body.[23]

The palatine process projects horizontally from the lower part of the medial surface to form the anterior two-thirds of the hard palate; its smooth upper surface lies in the floor of the nasal cavity while its lower surface forms the roof of the mouth. At the two ends of its medial border are the nasal crest and anterior nasal spine, which support the nasal septum. The maxilla seen from various angles is shown.

The landmarks to be most carefully studied and avoided in a maxilla is the maxillary sinus, or antrum of Highmore and the nasal cavities.

This sinus is an airfilled chamber that is an extension of the nasal cavity.

It is lined with a mucous membrane that is continuous with that of the nasal cavity. The posterior superior dental, infra orbital, and anterior superior dental nerves and their accompanying vessels lie in the mucosa of the posterior wall, roof, and anterior wall of the sinus, respectively.

In the adult, the maxillary sinus is a large, pyramid shaped cavity with its apex in the zygomatic process of the maxilla and its base at the lower part of the lateral wall of the nose. The roof of the sinus is the floor of the orbit, and its own narrow floor lies over the alveolar process in the region of the molar and premolar teeth. The sinus is irregular in shape. Normally its deepest part lies over the second premolar and first molar teeth. However, its floor may extend no farther than the three molars, or it may extend as far forward as the canine teeth. The roots of the teeth, particularly the first two molars, may produce eminences in the floor and even penetrate the sinus.[24]

Usually the sinuses are symmetrical, that is, the left maxilla is approximately the same size and shape as the right maxilla. Differences, however, are not rare. The sinuses are normally larger in men than in women, and they serve to lighten what would otherwise be rather heavy bone. At birth the sinus is no more than a groove by the lateral wall of the nasal fossa. Growth, which is accompanied by an evagination of the mucous membrane of the nose, is slow because there is little room for enlargement of the sinus until the teeth erupt and the alveolar process matures.[21]

Thus, at the age of 1 year, the sinus is small triangle still medial to the infraorbital foramen, hugging the wall of the nasal fossa. It gradually enlarges. By the sixth year it has reached the level of the middle meatus. Between the ages 8 and 12, the mature teeth erupt and the sinus expands gradually until its floor reaches the same level as the floor of the nose. By the fifteenth to eighteenth year, the sinus rapidly assumes its full size, at which time the sinus floor is at the level of the alveolus.

As in the mandible, the amount of alveolar bone in the adult determines the location of the floor of the sinus. In a young adult possessing all his teeth, the sinus floor is usually separated by alveolar bone about 1 cm deep in the lateral maxillary sinus region and 1.2 cm. in the anterior nasal region. The width of the alveolar crest increases from front to rear, with the maximum width usually at the level of the last molar and wisdom teeth. As teeth are lost, the alveolar bone recedes inferiorly, lowering the sinus floor and buccally, narrowing the ridge. In the edentulous patient with marked alveolar bone resorption, only a thin layer of bone may divide the sinus from the mouth. Again, the approach to an endosseous implant procedure is determined by the extent of alveolar bone and the location of a landmark, this time the sinus.[21]

Bone Density: A Key Determinent for Clinical Success

Available bone is particularly important in implant dentistry and describes the external architecture or volume of the edentulous area considered for implants. In addition, bone has an internal structure described in terms of quality or density, which reflects the strength of the bone. The external and internal architecture of bone controls virtually every facet of the practice of implant dentistry. The density of available bone in an edentulous site is a determining factor in treatment planning, implant design, surgical approach, healing time, and initial progressive bone loading during prosthetic reconstruction.

Clinical Evidence Documents Influence of Bone Density on Success Rates

Multiple, independent groups have reported higher failure rates in poor quality bone compared to higher quality bone. Following a standard surgical and prosthetic protocol, Adell *et al*. reported an approximate 10% greater success rate in the anterior mandible as compared to the anterior maxilla. Lower success was also noted in the posterior mandible as compared to the anterior mandible when the same protocol was followed by Schnitman *et al*. The highest clinical failure rates have been reported in the posterior maxilla. Hence, a range of implant survival has been found relative to location.

The anterior mandible has greater bone density than the anterior maxilla. The posterior mandible has poorer bone density than the anterior mandible. The poorest bone quality in the oral environment typically exists in the posterior maxilla, and it is associated with dramatic failure rates. Jaffin and Berman reported a 44% failure when poor density was observed in the maxilla, with the majority of failures noted at second-stage surgery. Fifty-five percent of all implant failures within their study sample occurred in the soft bone type. The report documented a 35% implant loss in any region of the mouth when bone density was poor. Engquist *et al*. also reported a high percentage of clinical failures, 78%, in soft bone types. Friberg *et al*. observed 66% of their group's implant failures occurred in the maxilla with soft bone. The reduced implant survival most often is more related to bone density than location. However, as a general rule, the posterior regions of the mouth have less dense bone than the anterior regions in both the maxilla and mandible.

Five independent clinical groups, following a standardized surgical protocol and using the same implant design, documented the indisputable influence of bone density on clinical success.

Bone Classification Schemes Related to Implant Dentistry

The appreciation of bone density and its relation to oral implantology have existed for more than 25 years. **Linkow, in 1970**, classified bone density into three categories.

Class I Bone Structure*:* This ideal bone type consists of evenly spaced trabeculae with small cancellated spaces.
Class II Bone Structure*:* The bone has slightly larger cancellated spaces with less uniformity of the osseous pattern.
Class III Bone Structure*:* Large marrow-filled spaces exist between bone trabeculae.

Linkow stated that Class III bone results in a loose-fitting implant; Class II bone was satisfactory for implants; and Class I bone was a very satisfactory foundation for implant prostheses.

In 1985, Lekholm and Zarb listed four bone qualities found in the anterior regions of the jawbone.[25]

Quality 1 was composed of homogeneous compact bone.
Quality 2 had a thick layer of compact bone surrounding a core of dense trabecular bone.
Quality 3 had a thin layer of cortical bone surrounding dense trabecular bone of favorable strength.
Quality 4 had a thin layer of cortical bonesurrounding a core of low-density trabecular bone.

Irrespective of the different bone qualities, all bone was treated with the same implant design and standard surgical and prosthetic protocol. Following this protocol results in 10% difference in implant survival between Quality 2 and Quality 3 bone and 22% lower survival in the poorest bone density. Jaffin and Berman reported 55% of all failures occurred in Quality 4 bone, with an overall 35% failure (44% failure when soft bone was found in the maxilla.). Engquist *et al*. observed 78% of all reported failures were in Quality 4 bone, and Friberg *et al*., observed 66% of all failures were in soft bone with severe resorption Clearly, this surgical, prosthetic, and implant design protocol does not render similar results in all bone densities. In addition, these reports are for implant survival, not the quality of health of remaining implants. The amount of crestal bone loss has also been related to stress and bone density.

In 1988, Misch extended four bone density groups independent of the regions of the jaws, based on macroscopic cortical and trabecular bone characteristics.The regions of the jaws with similar densities were often consistent.[26]

Suggested implant design, surgical protocol, healing, treatment plans, and progressive loading time spans have been described for each bone density type. Following this regimen, similar implant survival rates are observed for all bone densities.

Misch Bone Density Classification

Dense and/or porous cortical bone are found on the outer surfaces of bone and include the crest of an edentulous ridge. Coarse and fine trabecular bone are found within the outer shell of cortical bone, and occasionally on the crestal surface of an edentulous residual ridge. These four macroscopic differences of bone may be arranged from the most dense to the least dense, as first described by Frost.

Misch Bone Density Classification

Bone	Density
D1	Dense cortical bone
D2	Thick dense to porous cortical bone on crest and coarse trabecular bone within
D3	Thin porous cortical bone on crest and fine trabecular bone within
D4	Fine trabecular bone
D5	Immature, nonmineralized bone

The macroscopic description of the Misch bone density classification of D1 bone is primarily dense cortical bone. D2 bone has dense-to-thick porous cortical bone on the crest and within coarse trabecular bone. D3 has a thinner porous cortical crest and fine trabecular bone. D4 bone has almost no crestal cortical bone. The fine trabecular bone composes almost all of the total volume of bone next to the implant. A very soft bone, with incomplete mineralization, may be addressed as D5 bone. This description is usually of immature bone. The bone density may be determined by tactile sense during surgery, the general location, or radiographic evaluation.[27]

Bone Density-Tactile Sense

In order to communicate more broadly to the profession related to the tactile sense of different bone densities, this classification is compared to materials of varying densities. Drilling and placing implants into D1 bone is similar to drilling into oak or maple wood. D2 bone is similar to the tactile sensation of drilling into white pine or spruce. D3 bone is similar to drilling into balsa wood.

D4 bone is similar to drilling into Styrofoam.

Bone Density Location

A review of the literature, blended with a survey of 200 completely and partially edentulous consecutive patients postsurgery found the location of different bone densities may be superimposed with the different regions of the mouth.[28]

D1 bone is almost never observed in the maxilla. In the mandible, D1 bone is observed approximately 8% of the time. D1 bone is observed twice as often in the anterior mandible compared with the posterior mandible (6% vs. 3%). The bone density reported is for Division A available bone conditions. As the bone is reduced in volume to C-h, especially in the anterior mandible, D1 bone will occur with greater frequency and may reach 25%, whereas D3 will be less and be reduced to less than 10%. The C-h mandible often exhibits an increase in torsion and/or flexure in the anterior segment between the foramina during function. This increased strain causes the bone to increase in density. D1 bone may be encountered in the anterior Division A mandible of a Kennedy Class IV partially edentulous patient with a history of parafunction and recent extractions. It may also be observed when the angulation of the anterior implant may require the engagement of the lingual cortical plate in a Division A bone volume.

The bone density D2 is the most common bone density observed in the mandible. The anterior mandible consists of D2 bone two thirds of the time. Approximately one half of patients have D2 bone in the posterior mandible. The maxilla presents D2 bone less often than the mandible. Approximately one fourth of patients have D2 bone, and this is more likely in the partially edentulous patient‘s anterior and premolar region rather than the completely edentulous posterior molar areas. Single-tooth or two-tooth partially edentulous spans almost always have D2 bone.[29]

Bone density D3 is very common in the maxilla. More than one half of the patients have D3 bone in the upper arch. The anterior maxilla has D3 bone about 65% of the time, whereas almost one half of the patients have posterior maxillae with D3 bone (more often in the premolar region). Almost one half of theposterior mandibles also presents with D3 bone, whereas approximately 25% of the anterior edentulous mandibles have D3 bone.

The softest bone, D4, is most often found in the posterior maxillae (approximately 40%), especially in the molar regions or after a sinus graft augmentation (where almost two thirds of the patients have D4 bone). The anterior maxilla has D4 bone less than 10% of the time, more often after an onlay iliac crest bone graft. The mandible presents with D4 bone in less than 3% of the patients. When observed, it is usually Division A bone in a long-term, completely edentulous patient after an osteoplasty to remove the crestal bone.

Generalizations for treatment planning can be made prudently, based on location. It is safer to error on the side of treatment planning for less dense bone, so the prosthesis will be designed with slightly more, rather than less, support. The anterior maxilla is usually treater as D3 bone, the posterior maxilla as D4 bone, the anterior mandible as D2 bone, and the posterior mandible as D3 bone. A more accurate determination of bone density can be made with computerized tomograms or tactiley during implant surgery.

Radiographic Bone Density

Periapical or panoramic radiographs are not very beneficial to determine bone density because the lateral cortical plates often obscure the trabecular bone density. In addition, the more subtle changes of D2 to D3 cannot be quantified by these radiographs.

Bone density may be more precisely determined by tomographic radiographs, especially computerized tomograms. Computerized tomography (CT) produces axial images of the patient‘s anatomy, perpendicular to the long axis of the body. Each CT axial image has 260,000 pixels, and each pixel has a CT number (Hounsfield unit) related to the density of the tissues within the pixel. In general, the higher the CT number, the denser the tissue. Modern CT scanners can resolve objects less than 0.5 mm apart.

The Misch bone density classification may be evaluated on the CT images by correlation to a range of Hounsfield units:

D1	**greater than 1250 units**
D2	850 to 1250 units
D3	350 to 850 units
D4	150 to 350 units
D5	less than 150 units

The very soft bone observed after some bone grafts may be 100 to 300 units. The bone density may be different near the crest, compared with the apical region where the implant placement is planned. The most critical region of bone density is the crestal 7 to 10 mm of bone. Therefore when the bone density varies from the most crestal to apical region around the implant, the crestal 7 to 10 mm determines the treatment plan protocol.

Bone Strength and Density

Bone density is directly related to the strength of bone before microfracture. Qu *et al*. reported on the mechanical properties of trabecular bone in the mandible, using the Misch density classification.[30] A tenfold difference in bone strength may be observed from D1 to D4 bone. D2 bone exhibited a 47% to 68% greater ultimate compressive strength, compared with D3 bone. Bidez and Misch performed three dimensional, finite stress analyses on bone volumes of Division A, B, and C-w patients. Each model reproduced the cortical and trabecular bone material properties of the four densities described. Clinical failure was mathematically predicted in D4 bone and some D3 densities under occlusal loads and may be related to bone volume.

Influence of Bone Density on Load Transfer

The initial bone density not only provides mechanical immobilization of the implant during healing, but after healing also permits distribution and transmission of stresses from the prosthesis to the implant-bone interface. The mechanical distribution of stress occurs primarily where bone is in contact with the implant. Open marrow spaces or zones of unorganized fibrous tissue do not permit as controlled force dissipation or physiologic increases in the density of the supporting bone. The smaller the area of bone contacting the implant body, the greater the overall stress, when all other factors are equal. The bone density influences the amount of bone in contact with the implant surface, not only at first stage surgery, but also at the second stage uncover and early prosthetic loading. The percentage of bone contact is significantly greater in cortical bone than in trabecular bone. The very dense bone of a C-h resorbed anterior mandible (D1) or of the lateral cortical bone of a Division A anterior mandible provides the highest percentage of bone in contact with an endosteal implant. The sparse trabeculae of the bone often found in the posterior maxilla (D4) offer less areas of contact with the body of the implant. Consequently, greater implant surface area is required to obtain a similar amount of bone implant contact in soft bone, compared with denser bone quality found around an anterior mandibular implant.

Crestal bone loss and early implant failure after loading results most often from excess stress at the implant-bone interface. A range of bone loss has been observed with similar loads on the implant.[31]

This phenomenon is explained by the evaluation of finite element analysis of stress contours in the bone. As a result of the correlation of bone strength and bone-implant contact, when a load is placed on an implant, the stress contours in the bone are different for each bone density. In D1 bone, most stresses are concentrated around the implant near the crest, and the stress is of lesser magnitude. D2 bone, with the same load, sustains a slightly greater crestal stress and the intensity of the stress extends farther apically, along the implant body. D4 bone exhibits the greatest crestal stresses, and the magnitude of the force of load on the implant proceeds farthest apically along the implant body. As a result, the magnitude of stress may remain similar and give one of the following three different clinical situations, based on bone density:

1. Physiologic bone loads and no bone loss
2. Pathologic bone loads and crestal bone loss
3. Severe pathologic loads and implant failure

Therefore to re-equilibrate the equation, treatment plans should be modified for each bone density.

SUMMARY AND CONCLUSIONS

The success and predictability of osseointegrated dental implants have forever changed the philosophy and practice of dentistry and perhaps more than any other specialty, periodontics has changed dramatically. In the past two decades, there has been a paradigm shift in the periodontics from the philosophy of saving teeth at all cost to one of extracting compromised teeth and replacing them with dental implant for a better and more predictable long term outcome.

Understanding both biological and surgical aspects of dental implant is important for the success rate of dental implant. Biologically implant design, biomaterial of dental implant, its interface with bone surface and bone are important factors whereas surgically placement of implant depends on the type of bone and area where it should be placed. As well as surgical placement depends on the implant system that is used.

The goal of biomaterials research has been and continued to develop implant materials that induce predictable, control guided and rapid healing of the interfacial tissues both hard and soft. The most critical aspect of biocompatibility is dependent on the basic bulk and surface properties and biomaterials.

Because oral implants are used to support or anchor a dental prosthesis, the abutment and restoration must emerge through the connective tissue and epithelium. Thus, it is important to understand the bone anatomy and soft tissue interface and shape and design of implant.

The various implant systems have their own specific armamentarium and recommendation for use but it is advisable to follow the detailed guideline and step by step description in the manufacture's manual for surgical placement of any implant.

Extraction of teeth and their replacement with implants are becoming increasingly frequent in the management of periodontally compromised patients. This approach is based on the assumptions that an implant performs better than periodontally compromised teeth and that their longevity is dependent of the individual susceptibility to periodontitis. However, recent studies suggest that periodontitis susceptible patients are also at a risk for developing peri-implantitis.

The bone of the alveolar process is of critical importance to maintain the structure and function of the jaws and subsequently the housing of teeth or tooth replacements. The physiological and biomechanical influences on bone by local and systemic mediators of bone homeostasis are important in the maintenance of alveolus. Reconstructive modalities aimed at the repair of bone tissues as a result of disease or injury utilized fundamental principle of bone biology. These regenerative biology approaches have been exploited in implant dentistry and periodontology with the use of bone grafting biomaterials, guided bone regeneration approaches, and more recently with polypeptide growth factors. Future work in this area will focus on the implications of the systemic disease on bone maintenance during function as well as more predictable modalities for alveolar bone reconstruction.

Today's arsenal of therapeutics makes the choice of best treatment strategy for the individual patient very sophisticated. As dental implants have become more predictable, the clinician is often confronted with the dilemma whether to use implants or other modalities. The survival and success rates reported by many implant investigators often exceed the success rates of some forms traditional dental treatment. In particular, it could be argued that implant – borne prosthesis have a better outcome than apical surgery, conventional endodontic re – treatment and conventional dentures.

The natural tooth must not be considered as an obstacle but a possibility, whether or not the treatment is to include implant installation. "Many roads lead to Rome" and that the dental team has a delicate palette of treatment options to consider, not least regarding the use of natural teeth vs implants in various prosthetic treatment plans.

References

1. Introducing Dental Implants: John A. Hobkirk, Roger M.Watson, Lloyd J.J. Searson, (foreword by- George A. Zarb): publication: Churchill Livingstone.
2. Palmer R. Introduction to dental implants. *Br Dent J.* 1999 Aug 14;187(3):127-32.
3. Bougas K, Jimbo R, Vandeweghe S, Tovar N, Baldassarri M, Alenezi A, Janal M, Coelho PG, Wennerberg A. In vivo evaluation of a novel implant coating agent: laminin-1. *Clin Implant Dent Relat Res.* 2014 Oct;16(5):728-35.
4. Spiekerman H. Color atlas of dental medicine. Implantology.pp V-VI. New York: Thieme Medical Publishers, Inc, 1995.
5. *Misch Carl E (2007). Contemporary Implant Dentistry. St. Louis, Missouri: Mosby Elsevier.*
6. Atwood DA. Reduction of residual ridges: a major oral disease entity. *J Prosthet Dent.* 1971 Sep;26(3):266-79.
7. Berglundh T, Abrahamsson I, Welander M, Lang NP, Lindhe J. Morphogenesis of the peri-implant mucosa: an experimental study in dogs. *Clin Oral Implants Res.* 2007 Feb;18(1):1-8.
8. Berglundh T, Lindhe J, Jonsson K, Ericsson I. The topography of the vascular systems in the periodontal

and peri-implant tissues in the dog. *J Clin Periodontol.* 1994 Mar;21(3):189-93.

9. Buser D, Dula K, Belser UC, Hirt HP, Berthold H. Localized ridge augmentation using guided bone regeneration. II. Surgical procedure in the mandible. *Int J Periodontics Restorative Dent.* 1995 Feb;15(1):10-29.
10. Cheng H, Jiang W, Phillips FM, Haydon RC, Peng Y, Zhou L, Luu HH, An N, Breyer B, Vanichakarn P, Szatkowski JP, Park JY, He TC. Osteogenic activity of the fourteen types of human bone morphogenetic proteins (BMPs). *J Bone Joint Surg Am.* 2003 Aug;85-A(8):1544-52.
11. Clinical Periodontology And Implant Dentistry, 5th Edition, Niklaus P. Lang & Jan Lindhe, Vol 2; Publication : Blackwell Munksgaurd.
12. Abrahamsson I, Berglundh T, Glantz PO, Lindhe J. The mucosal attachment at different abutments. An experimental study in dogs. *J Clin Periodontol.*1998 Sep;25(9):721-7.
13. Ash MM. Wheeler's Dental Anatomy, Physiology and Occlusion. Philadelphia: Saunders, 1984; 138-53.
14. Fransson C, Lekholm U, Jemt T, Berglundh T. Prevalence of subjects with progressive bone loss at implants. *Clin Oral Implants Res*. 2005 Aug;16(4):440-6.
15. Ellingsen JE, Johansson CB, Wennerberg A, Holmén A. Improved retention and bone-to lmplant contact with fluoride-modified titanium implants. *Int J Oral Maxillofac Implants.* 2004 Sep-Oct;19(5):659-66.
16. Friberg B, Ivanoff CJ, Lekholm U. Inferior alveolar nerve transposition in combination with Brånemark implant treatment. *Int J Periodontics Restorative Dent.* 1992;12(6):440-9.
17. Friberg B, Ekestubbe A, Mellström D, Sennerby L. Branemark implants and osteoporosis: a clinical exploratory study. *Clin Implant Dent Relat Res.* 2001;3(1):50-6.
18. Friedenstein, A.J. Determined and inducible osteogenic precursor cells. In: Hand Tissue Growth Repair and Reminer-alisation. *Ciba Foundation Symposium. New series* 1973; 11: 169-181.
19. Ekelund JA, Lindquist LW, Carlsson GE, Jemt T. Implant treatment in the edentulous mandible: a prospective study on Brånemark system implants over more than 20 years. *Int J Prosthodont.* 2003 Nov-Dec;16(6):602-8.
20. Gargiulo AW, Wentz FM, Orban BJ. Dimensions and relations of the dentogingival junction in humans. *J Periodontol* 1961;32:261-76.
21. Friberg B, Ekestubbe A, Mellstrom D, Sennerby L. Brånemark implants and osteoporosis: a clinical exploratory study. *Clin Implant Dent Relat Res.* 2001;3(1):50-6.
22. Giannobile WV. Periodontal tissue engineering by growth factors. *Bone.* 1996 Jul;19(1 Suppl):23S-37S.
23. Schmid J, Hämmerle CH, Flückiger L, Winkler JR, Olah AJ, Gogolewski S, Lang NP. Blood-filled spaces with and without filler materials in guided bone regeneration. A comparative experimental study in the rabbit using bioresorbable membranes. *Clin Oral Implants Res*. 1997 Apr;8(2):75-81.
24. Giannobile & Somerman 2003; Reynolds *et al*. 2003 (Harms J, Mausle E: Biokompatibiiitat von implanten in der Orthopädie, Hefte Unfalheilkd 1980; 1:144-50.
25. Jaffin RA, Berman CL. The excessive loss of Branemark fixtures in type IV bone: a 5-year analysis. *J Periodontol.* 1991 Jan;62(1):2-4.
26. James RA, Kelln EE. A histopathological report on the nature of the epithelium and underlying connective tissue which surrounds oral implants. *J Biomed Mater Res.* 1974;8(4 Pt 2):373-83.
27. Kan JY, Rungcharassaeng K, Umezu K, Kois JC. Dimensions of peri-implant mucosa: an evaluation of maxillary anterior single implants in humans. *J Periodontol*. 2003 Apr;74(4):557-62.
28. Kribbs PJ, Chesnut CH 3rd, Ott SM, Kilcoyne RF. Relationships between mandibular and skeletal bone in a population of normal women. *J Prosthet Dent*. 1990 Jan;63(1):86-9.
29. Lekholm U, Zarb GA, Branemark P-I, Zarb GA, Albrektsson T, editors: Tissue integrated prostheses: *osseintegration in clinical dentistry* 1985;199-209,Quintessence.
30. Linkow LI, Wertman E. Re-entry implants & their procedures. *J Oral Implantol.* 1986;12(4):590-626.

How to cite this article:

Amit Daityari *et al*.2018, Biological Considerations of Dental Implants: A Literature Review. *Int J Recent Sci Res.* 9(1), pp. 22898-22907. DOI: http://dx.doi.org/10.24327/ijrsr.2018.0901.1358

****