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Effect bone density on implant successful

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بسم الله الرحمن الرحيم

اقرأ باسم ربك الذي خلق

Certification of the Supervisor

I certify that this project entitled **effect bone density on implant *successful*** was prepared by the fifth-year student under my supervision at the College of Dentistry/University of Babylon in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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Aim of study

To evaluation bone density on implant *successful* and which type of bone better for implant

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1.1 Introduction :

Implant stability

Implant stability, an indirect indication of osseointegration is a measure of the clinical immobility of an implant (Digholkaret al., 2014). Obtaining and maintaining this implant stability is a prerequisite for a successful clinical outcome. Therefore implant stability measurement is important for evaluation success of an implant (Satwalekar et al., 2015).

Implant stability types

Implant stability is achieved at two different stages:

1. **Mechanical (Primary) implant stability**, which is the result of holding the implant firmly in place by compressed bone. In other words, it is a frictional force between the bone and the implant. It is resulted from
the insertion force of the implant in the bone (biomechanical bone-
implant relation) (Sennerby, 2015;Mohajerani et al., 2015;
Konstantinović et al., 2015).

2.**Biological (Secondary) implant stability**, which is the result of osseointegration. In other words, it is a biological force developed from newbone cells formation around the implants (Sennerby, 2015; Mohajerani et al..2015).

So the implant final stability degree is resulted from the sum of the two as a result of bone remodeling types of stability (primary and secondary),initial
primary mechanical stability is augmented and/or replaced by
biological secondary stability. There is likely to be an initial decline in stability followed by a subsequent elevation as the implant becomes biologically
stable (Sennerby,2015).

Influence of Bone Density on Implant Success Rates The quality of bone is
often dependent on the arch position. The densest bone is usually observed in the anterior mandible, followed by the anterior maxilla and posterior mandible, and the least- dense bone is typically

found in the posterior maxilla. Following a standard surgical and prosthetic protocol, Adell et al.8 reported an approximately 10% greater success rate in the anterior mandible compared with the anterior maxilla. Schnitman et al.9 also noted lower success rates in the posterior mandible compared with the anterior mandible when the same protocol was followed. The highest clinical failure rates have been reported in the posterior maxilla, where the force magnitude is greater and the bone density is poorer Therefore, the
literature is quite abundant on implant survival relative to the arch position. In addition to arch location, several independent groups have reported different failure rates related to the quality of the bone

.2. Factors Influencing implant stability

In general factors influencing primary stability could be summarized by bone density, surgical technique including the surgeon skill and implant factors(geometry, length, and diameter and implant surface treatments); while the factors that influence secondary stability are; Primary stability,bone modeling and remodeling (Digholkar et al., 2014).

•2.1 Bone density

Bone density is frequently referred to as the amount (and their topographic relationship) of cancellous and cortical bone in which the recipient site is drilled. A poor bone density have been considered as the main risk factors for implant failure since it may be associated with excessive bone resorption and impairment in the healing process, compared with higher density bone(Patil and Bharadwaj, 2016).

The hardness of compact bone Is about ten times higher than can cello(trabecular) bone, owing to both its density and mineralization. The higher bone density gives the higher primary implants stability values (Konstantinović et al.,2015). Some authors have shown strong correlation between ISQ value and Cortical bone thickness, which suggests that cortical bone thickness plays an important role for primary stability (Roze et al., 2009).

2.2 Influence of Bone Density on Implant Success Rates :

The quality of bone is often dependent on the arch position. The densest bone is usually observed in the anterior mandible, followed by the anterior maxilla and posterior mandible, and the least- dense bone is typically found in the posterior maxilla. Following a standard surgical and prosthetic protocol, Adell et al.8 reported an approximately 10% greater success rate in the anterior mandible compared with the anterior maxilla. Schnitman et al.9 also noted lower success rates in the posterior mandible compared with the anterior mandible when the same protocol was followed. The highest clinical failure rates have been reported in the posterior maxilla, where the force magnitude is greater and the bone density is poorer Therefore, the literature is quite abundant on implant survival relative to the arch position. In addition to arch location, several independent groups have reported different failure rates related to the quality of the bone

2.3.Bone Classification Schemes Related to Implant Dentistry

Lekholm and Zarb (1985): Bone quality is categorized into four groups: groups 1-4 or type I to IV (Bone Quality Index-BQI)

Type 1: homogeneous cortical bone;

Type II: thick cortical bone with marrow cavity;

Type III: thin cortical bone with dense trabecular bone of good strength;

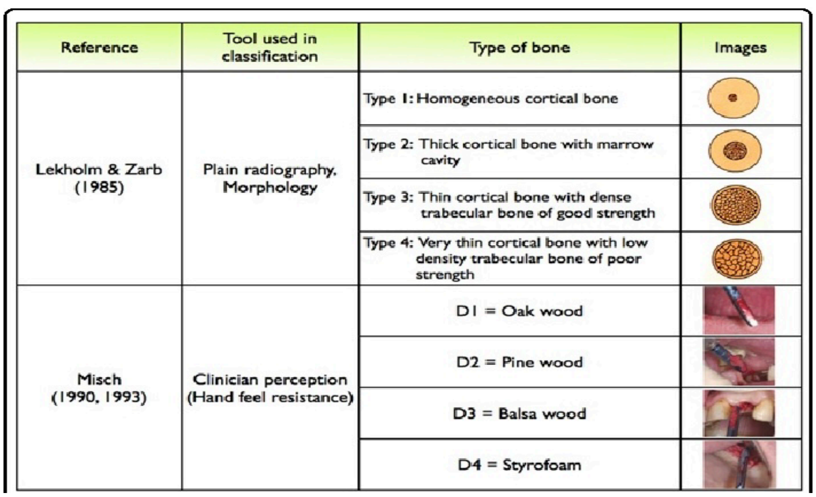
Type IV: very thin cortical bone with low density trabecular bone of poor strength

Misch (1990)-(2008): According to Misch classification, bone type was defined according to four density groups (D1-D4) in all regions of the jaws based on descriptive morphology and clinician tactile analog. Lately, these data were used to compare with anatomical location and radiographic scale (Lee et al., 2007).

Bone density can be determined by the general location, radiographic evaluation or by tactile sense during surgery. Generally, the anterior mandible is mostly D2 bone while posterior mandible is D3; the anterior maxilla is D3 and the posterior maxilla frequently D4 bone. However, resorbed anterior mandibles may be DI and the posterior maxilla may be D3 bone after 6 months following sinus graft in the majority of patients (Misch, 2008b). However, a D5 bone category may be addressed to a very soft bone, with large inter-trabecular spaces and incomplete mineralization (Misch, 2008a).

Misch proposed that computed tomography (CT), expressed in Houns field Units (HU), can be precisely utilized for the objective quantification of the measurements of bone density. A common way to evaluate bone density is during surgery. The density of bone could be determined through the initial bone drill with continuous evaluation until the final drill preparation (Misch. 2008b).

DI bone type is the strongest one and has the highest bone-implant contact (BIC) making it the most suitable for occlusal loading. D2 bone offers excellent implant interface healing with highly predictable osteointegration. With D3 type, usually there is a high risk of implant failure and small diameter implants are not recommended in this area. D4 type of bone is commonly associated with high rate of failure (Misch, 2008b).



Reference	Tool used in classification	Type of bone	Images
Lekholm & Zarb (1985)	Plain radiography, Morphology	Type 1: Homogeneous cortical bone	
		Type 2: Thick cortical bone with marrow cavity	
		Type 3: Thin cortical bone with dense trabecular bone of good strength	
		Type 4: Very thin cortical bone with low density trabecular bone of poor strength	
Misch (1990, 1993)	Clinician perception (Hand feel resistance)	D1 = Oak wood	
		D2 = Pine wood	
		D3 = Balsa wood	
		D4 = Styrofoam	

figure1.Representing techniques and reference used in bone Classification in dentistry (seriwatanachai et., 2015)

2.4 Relation between bone density and primary implant stability

Bone density is a key factor to take into account when predicting implant stability. Clinical studies show greater implant survival in the mandible than in the upper maxilla, due to the area's characteristics. This survival is limited by bone density (Farré-Pagès et al., 2011).

Several studies corroborate a higher failure rate of implants placed in type IV bone; as well, they found good results with implants placed in type I, II, and III bone, the latter being the optimal type of bone for adequate implant stability. Bone density and implant stability are important factors for implant osseointegration, which has been widely demonstrated by several studies (Molly, 2006).

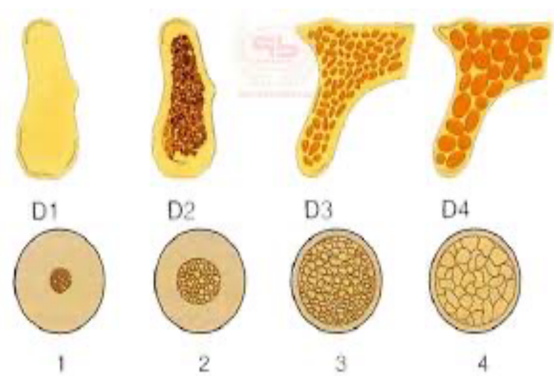


Figure 2. Jaw bone standard is suitable for dental implants

5.Location

A review of the literature and a survey of completely and partially edentulous patients postsurgery indicated that the location of different bone densities often may be superimposed on the different regions of the mouth

D1 bone is almost never observed in the maxilla and is rarely observed in most mandibles In the

mandible, D1 bone is observed approximately 6% of the time in the Division A anterior mandible and 3% of the time in the posterior mandible, primarily when the implant is engaging the lingual cortical plate of bone. In a C−h bone volume (moderate atrophy) in the anterior mandible the prevalence of D1 bone approaches 25% in male individuals. The C−h mandible often exhibits an increase in torsion, flexure, or both in the anterior segment between the foramina during function. This increased strain may cause the bone to increase in density. D1 bone also 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. In addition, D1 bone has been observed in the anterior or posterior mandible when the angulation of the implant may require the engagement of the lingual cortical plate.

The bone density D2 is the most common bone density observed in the mandible The anterior mandible consists of D2 bone approximately two-thirds of the time. Almost 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 in either arch almost always have D2 bone.

Bone density D3 is common in the maxilla More than half of patients have D3 bone in the upper arch. The anterior edentulous maxilla has D3 bone approximately 75% of the time, whereas almost half of the patients have posterior maxillae with D3 bone (more often in the premolar region). Almost half of the posterior mandibles also present 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 maxilla (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

6.Tactile Sense

There is a great difference in the tactile sensation during osteotomy preparation in different bone densities, because the density is directly related to its strength.To communicate more broadly to the profession relative to the tactile sense of differ- ent bone densities, Misch1,2 proposed the different densities of his classification be compared with materials of varying densities. Site preparation and implant placement in D1 bone is similar to the resistance on a drill preparing an osteotomy in oak or maple wood (e.g., hard wood). D2 bone is similar to the tactile sensation of drilling into white pine or spruce (e.g. soft wood). D3 bone is similar to drilling into a compressed balsa wood. D4 bone is similar to drilling into a compressed Styrofoam. This clinical observation may be correlated to different histomorphometric

7.Bone Strength and Density

Bone density is directly related to the strength of bone before micro fracture. Misch et al.78 reported on the mechanical properties of trabecular bone in the mandible, using the Misch density

classification. A ten fold 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 In other words,on ascale of 1 to10,D1bone is a9to10 relativeto strength.D2 bone is a7to8on this scale.D3 bone is 50%weaker thanD2 bone and is a 3or4 on the strength scale.D4 bone is a 1to2 and up to 10 times weaker than D1 bone Misch and Bidez 81 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

When the stresses applied to the implant are low, the microstrain difference between titanium and bone is minimized and remains in the adapted win- dow zone, maintaining load-bearing lamellar bone at the interface

Misch et al. found the elastic modulus in the human jaw to be different for each bone density

As a result, when a stress is applied to an implant prosthesis in D1 bone, the titaniumD1 bone interface exhibits a very small microstrain difference. In comparison, when the same amount of stress is applied to an implant in D4 bone, the microstrain difference between titanium and D4 bone is greater and may be in the pathologic overload zone . As a result, D4 bone is more likely to cause implant mobility and failure

Surgical Failure

There are many reasons for the failure of an implant to inte- grate initially with the bone. The primary causes of early failure relate to excessive heat during the preparation of the osteotomy or excessive pressure at the implant–bone interface at the time of implant insertion 23 The excessive pressure (i.e., pressure necrosis) at implant insertion is observed most often in more

dense bone (e.g., D1 or D2) with a greater thickness of cortical bone. An additional cause of surgical failure is micro movement of the implant while the developing interface is established A fractured arm is immobilized to prevent movement at the fracture site to decrease the risk of a fibrous nonunion. Movement as little as 20 microns has been reported to cause a fibrous interface to form at the fracture site. Brunski observed a fibrous tissue interface development when a dental implant moved more than 100 microns during initial healing.24 The original Bråne- mark protocol used a two-stage surgical approach for the most part to avoid any undue pressure.25,26 One of the main reasons for this concept was to place the implant at or below the crestal bone region to decrease the risk of implant movement during ini- tial bone healing. Schroeder also suggested an unloaded healing period on implants, although the implant was placed at or slightly above the gingival tissues.27 Occlusal forces applied to an interim removable prosthesis over a healing

implant may also cause incision line opening of the soft tissue and delay soft tissue healing.28 These occlusal forces may also affect the marginal bone around the developing implant site. Transferring these forces to an overly- ing soft tissue – borne prosthesis may cause micromovement of the implant–bone interface, whether the implant is healing below or documented in many studies. Isidor and colleagues allowed eight implants to integrate in monkey jaws.30 Crowns were attached to the healed implants with excessive premature occlusal contacts. Over a 20-month period, six of eight implants failed (Fig. 7.4). In these same animals, eight integrated implants with no occlusal loads had strings placed in the marginal gingiva to increase the amount of plaque retention. None of these implants failed over the next 20 months. The authors concluded that in this animal model, biome- chanical occlusal stress was a greater risk factor for early implant failure than the biological component of bacterial plaque.30,31

The morbidity of early loading failure is worse for the implant clinician than when a surgical failure occurs because the patient may lose confidence in the restoring dentist. In addition, there exists a significant financial and time commitment. Early load- ing failure is directly related to the amount of force applied to the prosthesis8,24,32-35 and the density of the bone around the implants,7,10-14,36 and it may affect up to 15% of implant restorations.6-11 Early implant failure from biomechanical overload, as high as 40%, has been reported in the softest bone types.13 No reports in the literature correlate such high incidence extreme with early implant failure rates related to the biological width-related complications observed in the field

8.Bone Density and Bone–Implant Contact Percentage

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

Therefore the BIC percent may influence the amount of stress/strain at the interface.

Misch noted in 1990 that 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 uncovery and early prosthetic loading. The BIC percentage is significantly greater in cortical bone than in trabecular bone. The very dense D1 bone of a C−h resorbed anterior mandible or of the lingual cortical plate of a Division A anterior or posterior mandible provides the highest

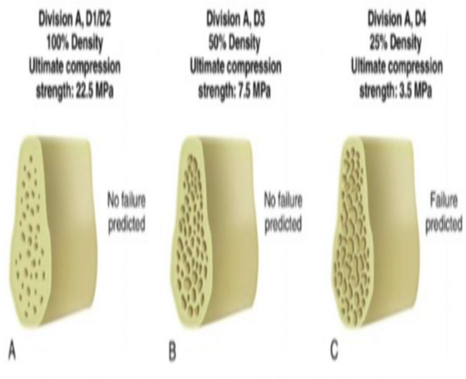


figure 3. Bone Density and Bone–Implant Contact Percentage

9.Bone density and quality In dental implantology

Quality of bone at implant sites

There is no clear definition of bone qualIty, but it Is generally presented as the sum of all of the characteristics of bone that influence its resistance to fracture (Fuh et al., 2010; Vasovic et al., 2015).

The term "bone quality" is commonly used In implant treatment and in reports on implant success and failure. Many authors define bone quality as equivalent to bone mineral density .Lindh et al in 2004 emphasized that bone density (bone mineral density) and bone quality are not the same. Bone quality encompasses factors other than bone density such as skeletal size, bone architecture, the 3D orientation of the trabecula, and matrix properties and not only a matter of mineral content, but also of structure. It has been shown thate quality and quantity of bone available at the implant site are very important pocal patient factors in determining the success of dental

Implants(Gulsahi.,2011; Jaju and Jaju, , 2014) .Although the clinical outcome of an Implant is

influenced by many factors, including the implant body, the skill of the surgeon, and the oral environment, the key factor for success is
the primary stability at the implant placement. Some studies have demonstrated that the quality of the alveolar bone is the most important
factor for achieving good primary stability (Tolstunov.,2007; Turkyilmaz et al., 2007; Vasovic et al., 2015).
The primary stability could be Increased with increased bone quality,which would improve the osseointegration and increase the survival probability of the dental implant. Poor bone quantity and especially poor bone quality are
the main risk factors for implant failure using the standard protocol for
implant insertion (Fuh et al., 2010; Vasovic et al., 2015).
The bone quality Is higher for the mandible than for the maxilla, and higher for the anterior region than for the posterior region of these bones. In addition,
the survival rate is higher for dental implants placed in the mandible than for those in the maxilla, particularly in the anterior region (Fuh et al., 2010;Gulsahi., 2011)

10..Divisions of Available Bone

Division A (Abundant Bone)

Division A abundant bone often forms soon after the tooth is extracted. The abundant bone volume remains for a varied amount of time that is dependent on many factors. Studies have shown the original crestal width may be reduced by more than 30% within 2 years.12 Division A bone corresponds to abundant available bone in all dimensions It should be empha sized that the available bone height may be greater than 20 mm for Division A, but this does not mean the implant length must be equal to the bone height. Because the stresses to the implant interface are dependent on bone density, the ideal implant length is bone-density and force-factor driven.

Division B (Barely Sufficient Bone)

As the bone resorbs, the width of available bone first decreases at the expense of the facial cortical plate, because the cortical bone is usually thicker on the lingual aspect of the alveolar bone, especially in the anterior regions of the jaws. Studies have shown a possible 25% decrease in bone width the first year and a 40% decrease in bone width within the first 1 to 3 years after tooth extraction. The resulting narrower ridge is often inadequate for many 4-mm-diameter root form implants. Slight-to-mild osseous atrophy is often used to describe this clinical condition. After Division B bone volume is reached, it may remain for more than 15 years in the anterior mandible. However, the posterior mandibular height resorbs four times faster than the anterior region. The posterior maxillary regions exhibit less available bone height (i.e., as a consequence of sinus expansion) and have the fastest decrease of bone height of any intraoral region. As a result the posterior regions of the jaws may become inadequate in height (C−h) earlier than the anterior regions.

Division B bone offers sufficient available bone height with compromised width.The Division B available bone width may be further classified into ridges 4 to 7 mm wide and B minus width (B−w) 2.5 to 4 mm wide, where bone grafting techniques are usually indicated The minimum mesiodistal width of a Division B ridge is less than that of Divi- sion A; a smaller-diameter implant (i.e., 3 mm) may be used depending on the area of concern and force factors.

Bone Spreading

An alternative for the augmentation approach for Division B bone is bone spreading. A narrow osteotomy may be made between the bony plates, and bone spreaders are sequentially tapped into the edentulous site. The Division B ridge may be expanded to a Divi- sion A with this technique and allow a Division A implant or an allograft to be inserted

Division C (Compromised Bone)

The Division C ridge is deficient in one or more dimensions (width, length, height, or angulation) regardless of the position of the implant body into the edentulous site. The resorption pattern occurs first in width and then in height. As a result the Division B ridge continues to resorb in width, although height of bone is still present, until it becomes inadequate for any design of endosteal implant. This bone category is called Divi- sion C minus width

(C−w) . The resorption process continues, and the available bone is then reduced in height (C−h).

Moderate-to-advanced atrophy may be used to describe the clinical conditions of Division C. The posterior maxilla or mandible result with Division C−h more rapidly than the anterior regions because the maxillary sinus or mandibular canal limit vertical height sooner than the opposing cortical plates in the anterior regions. When the anterior mandible is C−h, the floor of the mouth is often level or below the residual mandibular crest of the ridge. During swallowing, it may prolapse over the residual crest and implant sites, causing constant irritation of the permu- cosal implant posts and impairing proper design of the prosthetic superstructures.
The doctor must appreciate that the C−w bone will resorb to a C−h ridge as fast as the A resorbs to B and faster than B resorbs to C−w. In addition, without implant or bone graft intervention, the C−h available bone will eventually evolve into Division D (severe atrophy). Many completely edentulous patients are treated with implants in the mandible and conventional dentures in the maxilla,
primarily because the mandibular C−h arch is more often the cause of patient complaint . However, the patient should be educated about the future maxillary bone loss that will render maxillary implant treatment almost impossible without advanced bone graft procedures before placement. The Division C edentulous ridge does not offer as many elements for predictable endosteal implant survival or prosthodontic management compared with Divisions A or B. Anatomic land- marks to determine implant angulations or positions in relation to
• DivisionC Premaxilla:SignificantridgeresorptionleadingtoaC-wandthenaC-hridge.
the incisal edge are usually not present; therefore greater surgical skill is required. The doctor and patient should realize that Divi- sion C ridge implant-supported prostheses are more complex and have slightly more complications in healing, prosthetic design, or long-term maintenance. On the other hand, the patients usually have greater need for increased prosthodontic support. In spite of the reduced bone volume, altered treatment plans that decrease stress can provide predictable, long-term treatment.

There is one uncommon subcategory of Division C, namely, C−a. In this category, available bone is adequate in height and width, but angulation is greater than 30 degrees regardless of implant placement . When present, this condition is most often found in the anterior mandible; other less- observed regions include the maxilla with severe facial undercut regions or the mandibular second molar with a severe lingual undercut. Root form implants placed in this bone category may be positioned within the floor of the mouth and compromise prosthetic reconstruction, speech, and comfort

Division D (Deficient Bone)

Long-term bone resorption may result in the complete loss of the residual ridge, accompanied by basal bone atrophy . Severe atrophy describes the clinical condition of the Division D ridge. At one time, it was believed that only the alveolar process would resorb after tooth loss and the basal bone would remain. However, bone loss may continue beyond the previous roots of teeth and even include the bone over the inferior mandibular nerve or the nasal spine of the maxilla. Basal bone loss eventually results in a completely flat maxilla. In the mandible the superior genial tubercles become the most superior aspect of the ridge. The mentalis muscle will lose much of its attachment, even though the superior portion of the muscle attaches near the crest of the resorbed ridge. The buccinator muscle may approach the mylohyoid muscle and form an aponeurosis above the body of

the mandible. The mandibular arch also presents with mental foramina and portions of the mandibular canal dehiscent. Therefore it is not infrequent that these patients report neurosensory deficits of the lower lip, especially during mastication. The CHS is greater than 20 mm, which is a significant force multiplier and can rarely be reduced enough to render long-term success

the poorest treatment outcome of all the divisions of bone. Fixed restorations are nearly always contraindicated, because the CHS is so significant. Completely implant-supported overdentures are indicated whenever possible to decrease the soft tissue and nerve complications, but require anterior and posterior implant sup- port, which almost always requires bone augmentation before implant placement. Bone augmentation for Division D is difficult to improve the CHS enough to warrant a fixed restoration unless there are favorable force factors. An RP-5 restoration is not suggested, because bone loss will continue in the soft tissue–sup- ported region of the overdenture, and usually the buccal shelf (primary stress bearing area) is not present.

The completely edentulous Division D patient is the most difficult to treat in implant dentistry. Benefits must be carefully weighed against the risks and complications. Although the practi- tioner and patient often regard this condition as the most desperate, these patients do not usually understand the possible chronic complications that may result (e.g., oral antral fistulae, deviated facial). If implant failure occurs, the patient may become a dental cripple—unable to wear any prosthesis and worse off than before treatment

Autogenous iliac crest bone grafts to improve the Division D are strongly recommended before any implant treatment is attempted.74 After autogenous grafts are in place and allowed to heal for 5 or

more months, the bone division is usually Division C−h or Division A, and endosteal implants may be inserted .

Autogenous bone grafts should always be indicated for the placement of implants, never to increase support for a denture. The autogenous bone grafts are not intended for improved denture sup- port. If soft tissue–borne prostheses are fabricated on autogenous grafts, studies have shown 90% of the grafted bone resorbs within 5 years as a result of accelerated resorption.75 Additional augmentation to compensate for this resorption is not indicated. Repeated relines, highly mobile tissue, sore spots, and patient frustration are all postoperative consequences.

11.Measurement of Available bone

Available bone describes the amount of bone in the edentulous area considered for implantation. It is measured in width, height,length, angulation, and crown height space

11.1Available Bone Height

The available bone height is first estimated by radiographic evaluation in the edentulous ideal and optional regions.The height of available bone is measured from the crest of the edentulous ridge to the opposing landmark. The anterior regions are limited by the maxillary nares or the inferior border of the mandible. Usually the anterior regions of the jaws have the greatest height, because the maxillary sinus and inferior alveolar nerve limit this dimension in the posterior regions. The maxillary canine eminence region often offers the greatest height of available bone in the maxillary anterior.54 In the posterior jaw region, there is usually greater bone height in the maxillary first premolar than in the second premolar, which has greater height than the molar sites because of the

concave morphology of the maxillary sinus floor. Likewise the mandibular first premolar region is commonly anterior to the mental foramen and provides the most vertical column of bone in the posterior mandible. However, on occasion, this premolar site may present a

reduced height compared with the anterior region, because of the mental foramen position or the anterior loop of the mandibular canal(when present) as it passes below the foramen and proceeds superiorly, then distally, before its exit through the mental foramen. The dilemma of available bone in implant dentistry involves the existing anatomy of the edentulous mandible and maxilla. The initial mandibular bone height is influenced by skeletal anatomy, with

angle Class II patients having shorter mandibular height, and angle Class III patients exhibiting the greatest height. The initial edentulous anterior maxillary available bone height is less than the mandibular available bone height. The opposing landmarks for the initial available bone height are more limiting in the posterior regions. The posterior mandibular region is reduced because of the presence of the mandibular canal, approximately situated 12 mm above the inferior border of the mandible The available bone height in an edentulous site is a crucial dimension for implant consideration, because it affects both implant length and crown height

11.2. Available Bone Width

The width of available bone is measured between the facial and lingual plates at the crest of the potential implant site. The crest of the edentulous ridge is most often supported by a wider base. In most areas, because of this triangular-shaped cross section, an osteoplasty can be performed that results in a greater width of bone, although of reduced height. However, the anterior maxilla

often does not follow this rule, because most edentulous ridges exhibit a labial concavity in the incisor area, with an hourglass configuration.

After adequate height is available, the next most significant criterion affecting long-term survival of endosteal implants is the width of the available bone. Root form implants of 4-mm crestal diameter usually require a minimum of 7 mm of bone width (4.0 mm + 2.0 mm buccal + 1.0 mm lingual) to ensure sufficient bone thickness and blood supply around the implant for predictable survival. These dimensions provide more than 1.5 mm of bone on the buccal side and at least 1.0 mm on the lingual side

11.3 Radiographical analysis :

Radiograph is helpful in assessment of implant stability by observing the process of osseointegration or peri-implant lesions. However, there are many limitations with the conventional periapical and panoramic views. The facial bone loss which precedes the mesiodistal bone loss cannot be viewed, the limitation with image resolution making standardized X-raysdifficult to achieve, distortion of images making quantitative measurements challenging the perceiving changes in the bone structure and morphology of the implant- bone interface unless over 30% to 40% bone demineralization has occurred are among the many few .

11.3.1 Role of radiographic imaging in treatment planning for dental implants :

Imaging is the integral part of preoperative implant assessment because it is one of the most accurate means by which the clinician can assess the morphologic features of the proposed fixture sites (Jayadevappa et al., 2010).

A preoperative radiographic evaluation aims to identify pathological lesions, assess the quantity and quality of the alveolar bone, identify critical structures at the poseats implant sites, and determine the orientation of the implants. Bone quantry and quality will influence the choice of implants with respect to their number, diameter, length and type. Preoperative radiographic assessment has assumed an increasingly important role in treatment planning for implant-suppprted prostheses. It often requires a more extensive radiographic examination than that used for other types of oral rehabilitation (Siu et al., 2010).

There are many factors that play a part in deciding which imaging modality is to be used. Normally, panoramic radiography is done to begin with.

This provides a complete image of the jaw along with the anterior and posterior regions of the mandible and maxilla. But if the panoramic radiography doesn't provide enough necessary information, a periapical radiograph is advised to get more details with accuracy. However, if both fail, a Computed Tomography (CT) or Cone Beam Computer Tomography (CBCT) must be used to get all possible information accurately (Siu et al., 2010; Vishanti and Rao,2013)

11.3.2 Panoramic radiography :

Panoramic radiography is vital for the initial evaluation of bone dimensions and detecting pathological conditions in treatment planning.

Panaromic radiography is a curved plane tomographic radiographic technique used to depict the body of maxilla and mandible, location and dimension of the lower one half of the maxillary sinus, nasal cavity, inferior alveolar canal and mental foramen in a single image .

This leads to distortion and magnification especially in the anterior region which can be up to 25%. Magnification varies to a greater extent in the horizontal direction (16%) than in the vertical direction (10%) due to the focus of projection. In the vertical plane, the efficient source of projection is the focal spot on the x-ray tube where as in the horizontal plane, it is the rotational center of the x-ray beam.

Thus the variation in the horizontal plane is because of the changing distance between the rotational center and the film and the changing rate of movement of the film to that of the x-ray beam. This problem results in a linear measurement error of approximately 3.0mm. However, when the magnification factor can be determined, these panoramic images have been shown to be reasonably accurate (within 1mm) for assessing the distance between the crest of the ridge and the superior border of the inferior alveolar canal .

Figure 4. Panoramic radiograph

Advantages of panoramic radiography :

1- Easy identification of opposing landmarks.

2- Easy assessment of vertical bone height.

3- Preliminary estimations of crestal alveolar bone and cortical boundaries can be made.

4-Performed with convenience, ease and speed.

5- Gross anatomy of the jaws and any related pathology can be evaluated .

Limitations of panoramic radiography :

1- Assessment of hard tissue morphology, bone density and quality is difficult because of the multiple overlapping images of other structures onto the jaws.

2- Does not provide information regarding the buccolingual cross-sectional dimension or inclination of the alveolar ridge.

3- Inaccurate assessment of mesiodistal distance due to inappropriate patient positioning and/or individual variations in jaw curvature.

4- Does not depict the spatial relationships between the structures and dimensional quantification of the implant site .

The technology transmission of **CBCT** to dentistry first happened in 1995.

Italian coinventors Tacconi and Mozzo developed a CBCT system for the maxillofacial region (Jaju & Jaju, 2014). CBCT was initially introduced for its role in the field of dental implantology, currently; the utility of CB encompasses field of dental implantology, oral surgery, orthodontics, endodontics, sleep apnea, temporomandibular joint disorders and periodontics (Tyndall & Rathore, 2008). Spatial resolution of CBCT is higher than multislice computed tomography (MSCT) and accuracy of vertical and horizontal measurements are the same as the measurements performed on

cadaver, it is imperative to keep in mind that the smallest possible field of view should be used and the entire image volume should be interpreted (Benavides et al., 2012).

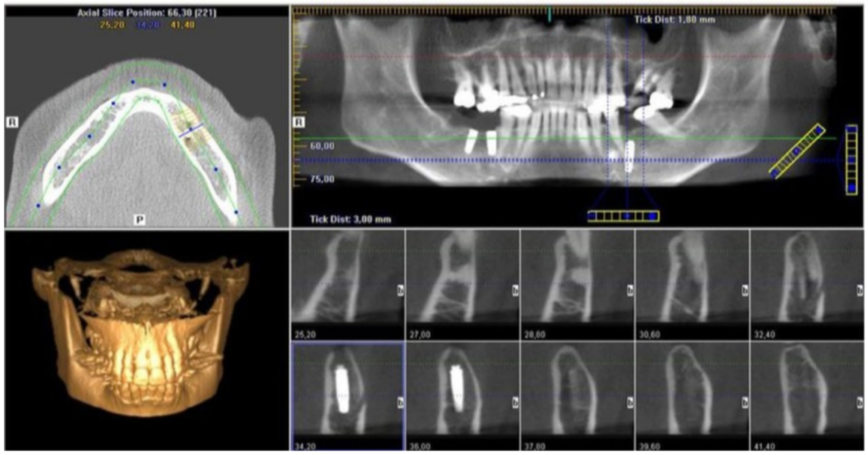


Figure 5. CBCT

A- Assessment of ridge morphology (type of alveolar ridge pattern).

B- CBCT- guided implant surgery (type, size and position of implant within bone, its relationship to the planned restoration, adjacent teeth and/or implants and its proximity to vital anatomical structures). Computer-generated surgical guides can be made-up from the virtual treatment plan (Jaju & Jaju, 2014).

The ability to slice through the 3-dimensional (3D) reconstruction provides interactive view verifying implant placement within the zone of (triangle of bone) as described by Gantz by using special simulating program so the amount of graft material needed could be calculated (Gantz, 2006).

C- Bone quality at potential implant sites: The term "bone quality" is commonly used in implant treatment and in reports on implant success and failure. Lindh et al., 2004 give emphasis to that bone density (bone mineral density, BMD) and bone quality are not the same. Bone quality encompasses factors other than bone density such as skeletal size, bone architecture, 3D orientation of the trabeculae and matrix properties and not only a matter of mineral content but also of structure (Jaju & Jaju, 2014). BMD could be measured effectively by CBCT (Kim, 2014).

D- Pre and postoperative assessment in advanced bone grafting procedures (e.g., sinus lift, block grafting, ridge splitting) (Benavides et al., 2012).

*** specific to MS observed in CBCT**

- Thickness of the lateral sinus wall, MS floor width. 2. Presence of AAA and its diameter. 3. MS septa. 4. Irregularity of sinus floor, intimate relation of Schneider membrane with the roots of the adjacent maxillary teeth.

- Assessment of the bone/biomaterial volume needed for sinus grafting (Rahpeyma & Khajehahmadi, 2015).

In their study Jaju & Jaju in 2014 demonstrated the superiority of CBCT over other imaging modalities namely; periapical and orthopantomography (OPG) and CT radiography, they developed a ranking score based on performance of the investigated imaging types in achieving the imaging goal and they assigned a numerical value at each score,

Limitations of CBCT

1- Amount of noise is higher than CT.

2- Artifacts created by metal objects (e.g., metal crown, DI).

3- Lack of accurate representation of the internal structure of soft tissues (museles, salivary glands, soft tissue lesions) (Benavides et al., 2012).

Grayscale for density estimation in CBCT

The grayscale represents the tissue attenuation coefficients that are based on density values for air, water and dense bone of arbitrary values -1000, 0, and +1000. For bone density measurement micro-CT is recommended as a gold standard for assessing bone morphology and micro-architecture (Burghardt et al., 2011; Ibrahim et al., 2013). However, it is limited to ex vivo small bone samples and cannot be employed for patients. MSCT is an established clinical modality in which calibrated Hounsfield units (HU) can precisely be converted to BMD measurements of five categories (DI >1250, D2-850-1250, D3=350-850, D4=150-350, D5<150 HU) (Shahlaie et al., 2003; Shapurian et al., 2006;

Misch, 2008). HU should be better understood as a relative density rather than true bone density (Hao et al., 2014). However, higher radiation exposure to patients in contrast with other modalities remains a main concern for applying MSCT for assessing bone quality (Frederiksen et al., 1995; Dula et al., 1996).

CBCT due to increased accessibility to dental practitioners, small footprint, reduced cost and radiation dose has broadly substituted medical CT for oral and maxillofacial imaging. Several studies reported high geometric accuracy of CBCT for linear measurement (Suomalainen et al., 2014), while its reliability in bone quality assessment remains controversial. Few studies suggested that CBCT could be applied to evaluate trabecular bone microstructure (Dos Santos Corpas et al., 2011; González García & Monje, 2013; Kim, 2014).

Moreover, CBCT does not represent calibrated voxel gray values expressed in

HU (Hua et al., 2009). Hao et al., 2014 indicated a strong correlation between the four regions of the alveolus of the mouth and bone density, beside that Parsa et al., 2015 confirms reliability of CBCT in trabecular microstructure evaluation.

Bone Classes	Description	Bone Density (HU)	Localization
D1	Dense cortical bone	> 1250	Anterior mandible
D2	Porous cortical bone and dense trabecular bone	850 – 1250	Anterior and posterior mandible; Anterior maxilla
D3	Thin and porous cortical bone and thin trabecular bone	350 – 850	Anterior and posterior maxilla; Mandible
D4	Thin trabecular bone	150 – 350	Posterior maxilla
D5	Non mineralized bone (unsuitable for implant)	< 150	–

Table 1 misch bone density classification scheme (misch,2008a).

Postgratting assessment

CBCT was used by Kim et al., 2013 to measure volumetric changes by determining the differences in Hounsfield values of bone tissues and the interior of the MS, such studies could evaluate volumetric changes more precisely than methods that only assess the alteration in the graft height by using panoramic radiographic images. Successful augmentation involved both creation of adequate bone to completely surround implants and clinically immobile upon exposure (Fugazzotto & Vlassis, 1998). Measurement of bone density in the most superior portion of the graft is significant as sinus lift healing and maturation depends on neovascularization that chiefly happens from the floor (Liversedge & Wong, 2002).

Radiological recommendations for DI surgery

The following recommendations made by the American Academy of Oral and Maxillofacial Radiology for the role of CBCT in dental implantology:

Recommendation 1: panoramic radiography should be used as imaging modality of choice in the initial assessment of the implant patient.

Recommendation 2: use intraoral periapical radiograph to complement the preliminary information from panoramic radiography.

Recommendation 3: do not use cross-sectional imaging modality including
CBCT as an initial diagnostic imaging investigation.

Recommendation 4; CBCT should be considered as t imaging modity of choice for preoperative cross sectional imaging of potential implant sites.

Recommendation 5; CBCT should be
considered when clinical conditions should a need for augmentation procedures or site development before placement of Die

1. Sinus augentation.
2. Block or particulate bone grahing
3. Ranus or symphysis grafting.
4. Assessment of impacted teth in the field of interest.

Recommendation 6: CBCT imaging should be considered if bone reconstruction and augmentation procedures (for example, ridge preservation or bone grafting) have been performed to treat bone volume deficiencies before implant placement.

Recommendation 7: use cross-sectional imaging (particularly CBCT)
immediately postoperatively, only if the patient presents with implant mobility or altered sensation, especially if the fixture is in the posterior mandible (Tyndall et al, 2012; Jaju & Jaju, 2014).

11.4 Dose considerations :

The chief concern of exposure to dental x-rays in general is the risk of potential stochastic effects which are those effects that could be caused regardless of how small the radiation exposure might be and include radiation-induced cancer and heritable effects. Risk versus benefit decision are made daily in a dental office. This risk is age dependent, being highest for the young and least for the elderly furthermore; At all ages; risks for females are slightly greater than males (Benavides et al., 2012). Effective dose from CBCT examinations ranges from 13 Sv to 479 Sv, for comparison the effective dose from one panoramic radiograph is about 10 to 14 Sv, while CT scan ranges from 474 to 1160 Sv (Loubele et al., 2009). The average background radiation is 3000 uSv (3 mSv) per year or 8 Sv per day. CBCT investigations must be justified on an individual basis by validating that the benefits to the patients be greater than the potential risks (Benavides et al., 2012).

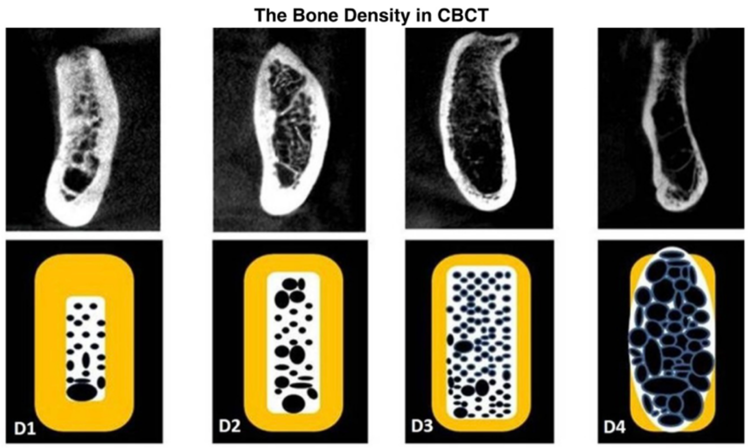


figure 6. The bone density in cbct

Prosthetic peri-implant complications may happen during different phases of treatment. From the diagnostic phase to the final restoration, relevant biological,mechanical, and functional principles must be followed to minimize the risk of complications. Implant-supported single crowns and multiple implant supported bridges may suffer from various mechanical, biological, or technical complications .Poor patient selection is one of the important factors that adversely contribute toward failures in implant dentistry

12.Mechanical complications

Mechanical complications are usually a sequel to biomechanical overloading.Factors contributing to the biomechanical overloading are poor implant position/angulation (cuspal inclination, implant inclination, horizontal offset of the implant, and apical offset of the implant),insufficient posterior support (i.e., missing posterior teeth), and inadequate available bone or the presence of excessive forces due to the parafunctional habits, that is, bruxism.

Screw Loosening

Abutment-screw loosening has been shown to be the most com-mon dental implant prosthetic complication, accounting for up to 33% of all postimplant prosthodontic issues.The incidence of screw loosening with single implant crowns has been reported as high as 59.6% within 15 years of placement.Unfortunately, screw loosening may cause many complications that contribute to crestal bone loss, screw fracture, implant fracture, or implant failure. Although screw loosening may occur in any area of the oral cavity, studies have shown the overwhelming majority of loosened screws occur in the maxillary and mandibular molar areas (~ 63%) and with single implant-crow restorations (~ 75%)

12.1 Screw/implant fracture

There are two major causes of implant fracture: biomechanical overloading and peri-implant vertical bone loss.The risk of implant fracture increases multifold when the vertical bone loss is severe enough to concur with the apical limit of the screw.Implant fractures are also attributable to flaws in the designs and manufacturing of implant itself.Unnoticed and recurrent screw loosening is a risk factor for dental implant fracture, which indicates change in the prosthesis design.

12.2 Cement failure

is another consequence of biomechanical overload, typically affects the prosthesis attachment and may be treated by recementation procedure.With the advancements in material science, particularly for luting agents, the incidence of decementation has reduced significantly.

Technical complications

The frequency of occurrences of technical complications is greater in implant supported FPDs as compared to the implant-supported removable prosthesis

Fracture of the framework : Whenever there is a rigid connection between the osseointegrated implant and the fixed subsequent framework, the strains are inevitably induced in every component of the framework.The additional functional load produces supplementary strains, which affect the bone-implant-prosthesis assembly.Hence, the challenge remains for a prosthodontist to deliver a tolerable prosthesis that does not jeopardize the endurance of the treatment. The problem of fracture of framework is reportedly exaggerated in partially edentulous jaws, because the implant-abutment interface and abutment retention screw are exposed to higher lateral bending loads, tipping, and elongation as compared to bilaterally splinted implants in a completely edentulous jaw.The length of the cast bar or framework span is directly

proportional to the construction-related distortion,which could get worsened by nonparallel placement of dental implants

Fracture of veneering porcelain

Fracture of the veneering ceramic is another common complication associated with single-implant restorations.The incidence of the fracture of the veneering ceramic can be reduced by following the clinical recommendations, that is, by reducing the occlusal table, preventing heavy occlusal contacts, keeping shallow cuspal heights, and by providing adequate thickness of the overlyin ceramic.

12.3 Peri-implantitis

Biological failures include bacterial infections, microbial plaque buildup, progressive bone loss, and sensory disruptions.Biological complications are subcategorized into early biological failures and late implant failures, where the early failures are attributed to the failure of placing the surgical implant under proper aseptic measures. and the late complications are typically peri-implantitis and infections bred by bacterial plaque

Conclusion:-

Causes of early implant failure include excessive heating of the bone during drilling, over-preparation of the surgical site or low-density bone D4 (is spongy bone, too porous bone) that interferes with the primary stability of the implant.
Adequate bone density is crucial for the success of dental implant surgery.D2 bone is the best bone for osseointegration of dental implants. It provides good cortical anchorage for primary stability, yet has better vascularity than D1 bone.

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