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Review Article

Key to Successful Implants- A Review of Literature

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ABSTRACT

Primary implant stability has been acknowledged as an essential criterion for later achievement of osseointegration. Dental implant stability is a measure of the anchorage quality of an implant in the alveolar bone and is considered to be the consequential parameter in implant dentistry. Implant stability can occurat two different stages: primary and secondary. It has been conclusively proved that stability both at placement and during function is an important criterion for the success of dental implants.

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INTRODUCTION

Forty five years ago, the first dental implant to replace a missing tooth in human oral cavity was reported (Brånemark et al. 1969)[1]. It was a sensational breakthrough in dentistry as it marked a new era to restore chewing function and aesthetics. Ever since, implant dentistry developed emphasizing aspects like dental materials, surface chemistry (Klokkevold et al. 1997[2], Salvi et al. 2004[3], Lazzara et al. 1999[4], Jansen et al. 1991[5]), surface characteristics (Buser et al. 1991[6], Abrahamsson et al. 2004[7], Carlsson et al. 1988[8]), as well as surgical soft and hard tissue biology.

The technique of placing titanium oral implants in healed edentulous sites and subsequently restoring the implant with a prosthesis has been recognized to be a highly predictive treatment for fully and partially edentulous patients. In general, the 5-year survival rate of implants is approximately 95%, and the 10-year survival rate is greater than 89% (Pjetursson et al. 2004)[9].

Primary implant stability has been acknowledged as an essential criterion for later achievement of osseointegration. Dental implant stability is a measure of the anchorage quality of an implant in the alveolar bone and is considered to be the consequential parameter in implant dentistry. Implant stability can occur at two different stages: primary and secondary [10].

It has been conclusively proved that stability both at placement and during function is an important criterion for the success of dental implants[11].

Primary stability is associated with the mechanical engagement of an implant with the surrounding bone, whereas bone regeneration and remodeling phenomena

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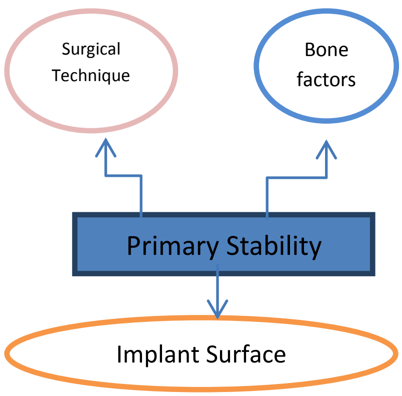
determine the secondary (biological) stability to the implant[12,13].



Primary impant stability at placement is a mechanical

phenomenon that is related to FIG 1

1) local bone quality and quatity

2) implant surface

3) surgical technique.

Surgical technique :

Under size drilling technique:

When evaluating whether the undersized drilling technique could enhance the primary implant stability, the two observational clinical studies [14,15] did not show a significant difference between the undersized drilling and the standard press-fit drilling techniques, but it was clearly in favour of the undersized group. The authors concluded that using thinner drills for implant placement in sites with poor bone density (posterior edentulous maxilla and mandible) is beneficial in enhancing primary implant stability. The higher primary stability of implants inserted after undersized drilling compared with those inserted after standard pressfit drilling might be interpreted by that the implants placed in undersized beds could compress the bone and increase its density, thereby enhancing the primary implant stability.

Osteotome Technique :

When evaluating what is the impact of using the osteotome in implant bed preparation on primary and/or secondary implant stability. Shayesteh et al.[16] and Markovi´c et al.[17] found positive association between using the osteotome technique and the primary implant stability. This increase in primary stability could be due to changes in the micromorphology of peri-implant trabecular bone caused by apicolateral condensation by osteotome. So, the primary stability is enhanced in this low density bone maybe due to increase in its density. In contrast, Padmanabhan and Gupta [18] demonstrated a statistically significant higher primary stability for implants placed with conventional drilling technique than those placed with osteotome in the maxillary anterior region.

Piezosurgery :

When evaluating whether using piezosurgery in implant bed preparation could influence the primary implant stability [19]. It demonstrated that there was no real difference in primary stability when implants were placed following piezoelectric technique versus the conventional twist-drill technique.

Flapless surgical technique :

When assessing the influence of flapless procedure on primary and/or secondary implant stability[20] . Concluding from this study, there was positive association between the flapless technique and the primary and secondary implant stability at three months after surgery. Interpreting this finding, it can be assumed that raising a mucoperiosteal flap and having the bone denuded during a certain time causes a postsurgical reaction and may have an impact on the bone remodeling around the implant . While the opposite occurs with flapless procedure where the bone remains covered by the periosteum; this may increase vascularity of the peri-implant mucosa, which furthermore appeared to be free from signs of inflammation.

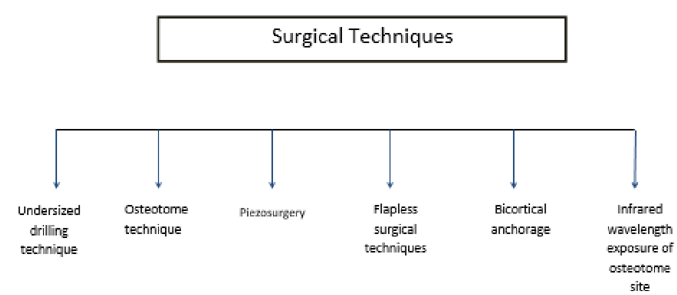
Exposure of osteotomy site with infrared wavelength :

There was a study done with exposure of the osteotomy site with 830-nm low-level laser[21] . It concluded that there was no evidence of any effect of irradiating bone osteotomies with infrared wavelengths on either primary and secondary implant stability within 12-week follow-up in the posterior mandible.

Immediate loading :

It has been reported high survival rates with the immediate loading of dental implants, which are attributed to high primary stability [22] .

A study by evaluated the effect of immediate loading on the primary stability of endosseous implants placed in the anterior incisor region by mapping the stability over a period of time, using resonance frequency analysis. It was concluded that immediate loading of implants placed in the maxillary and mandibular incisor region did not seem to affect the osseointegration of the implants which showed a high primary stability[23].



Bone quality and quantity :

Bone quality is often referred to as the amount of cortical and cancellous bone in which the recipient site is drilled. A poor bone quantity and quality have been indicated as the main risk factors for implant failure as it may be associated with excessive bone resorption and impairment in the healing process compared with higher density one[24,25]

A positive correlation was found between primary stability and cortical thickness of the artificial bone. In case of a poor supportive capacity of bone , compared with the implant diameter, a smaller drill diameter should be chosen, as from the findings of the present study it can be assumed that the undersized drilling technique locally optimizes the bone density and consequently improves the primary stability[26].

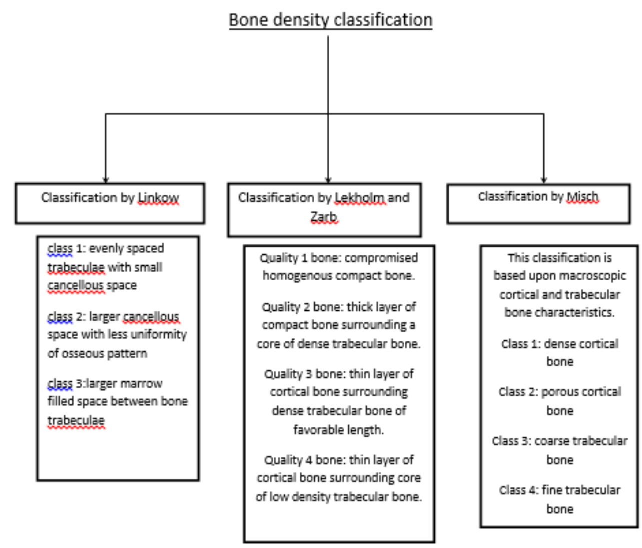
Results by Miyamoto et al.[27] demonstrated that dental implant stability is positively associated with the thickness of cortical bone thickness. In contrast to the previous studies, additional studies in the posterior mandible showed high failure rates due to the poor bone quality as well as other additional factors [28,29].

Computerized tomography (CT) has been regarded as the best radiographic method for analyzing the morphological and qualitative analysis of the residual bone [30]. It is also a valuable means for evaluating the relative distribution of cortical and cancellous bone[31].

Bi-cortical anchorage was put forth from a clinical aspect, that is, the buccal (lingual) modality, in which a wide-diameter implant is suggested to be placed in a slightly buccal (lingual) position to engage buccal (lingual) compact bone. It is speculated that this pattern of anchorage has beneficial effects on stabilizing the immediately loaded implants against deteriorative micro-motion at bone-implant interface in the initial phase of bone adaptation[32].

Bone density and common location

Bone type	D_1	D_2	D_3	D_4
Tactile sense	Oak or Maple	Pine or Spruce	Balsa wood	Styrofoam
Histology	Dense cortical bone	Dense to porous cortical & dense trabecular	Porous cortical & fine trabecular bone	Little cortical &fine trabecular
Usual location	Ant. Mandible 6% Post. Mandible 3%	Ant. Mandible 66% Post. Mandible 55% Ant maxilla 25%	Ant. Maxilla post. Maxilla	Post. Maxilla



Influence of implant surface and design:

Joe Merheb et al. in their study performed resonance frequency analysis (RFA) test at implant placement, and RFA and PTV were scored at loading. Bone density [Hounsfield (HU) scores] and coronal cortical thickness at osteotomy sites were measured from pre-operative computerized tomography scans. They concluded that the implant length or diameter did not seem to influence primary stability when considered as single parameters. However, in a stepwise multiple regression analysis, both parameters became significant probably due to the elimination of the confounding influence of the cortical thickness and/or the impact of bi-cortical anchorage[33].

The implant diameter, however, was shown to affect the RFA scores significantly at loading and confirms therefore the tendency to use wider implants in zones of poor bone quality or poor anchorage to improve success by increasing the possible bone to implant contact.

Implant design refers to the three-dimensional structure of an implant with all the components and features that characterize it. It has been reported that the implant design is a vital parameter for attaining primary stability[34]

Machined surface :

The first generation of osseointegrated implants had a relatively smooth machined surface[35] .The healing around the implant is characterized by an increase in bone-implant contact starting at the implantation while the biomechanical stability slightly decrease over the first weeks, possible due to inflammation and bone remodeling, and being fully recovered after 4 weeks in rat tibia[36]. Endosteal down growth of bone tissue covering the implant threads occurs in the marrow cavity and reach up to 70% bone implant contact after 16 weeks in rat tibia which could be compared to clinically stable oral implants retrieved up to 16 year after implantation where the bone-implant contact was measured to 56-85% [37]

Sand Blasting :

Increased roughness of an implant could be achieved by blasting the surface by small particles, usually called sandblasting or grit blasting. When the particles hit the implant surface it will create a crater. The surface roughness is hence dependent on the bulk material, the particle material, the particle size, the particle shape, the particle speed and the density of particles. Implants blasted with 25 μm and 75 μm particles show higher removal torque compared to a machined implant surface after 12 weeks of healing in either rabbit tibia or femur[38].

Acid etching :

With acid etching the surface is pitted by removal of grains and grain boundaries of the implant surface, as certain phases and impurities are more sensitive to the etching a selective removal of material is obtained. Significantly higher bone-implant contact was observed for acid etched implants compared to machined implants in a rabbit model after 1 and 2 months, while no difference was found after 14 days[39]. Significantly increased removal torque was needed to remove acid etched implants compared to the machined implant after 1, 2 and 3 months healing in rabbit while significantly lower removal torque was needed when comparing to titanium plasma sprayed implants [40].

Acid etching + sand blasting :

Commercially available dental implants are usually both blasted by particles and then subsequent etched by acids. This is performed to obtain a dual surface roughness as well as removal of embedded blasting particles.

Significantly higher removal torque and higher bone-implant contact has been observed for blasted and fluoride modified implants compared solely blasted implants in a rabbit model after 1 and 3 months healing [41].

Anodized surface :

The structural and chemical properties could be tailored by varying different process parameters, such as anode potential, electrolyte composition, temperature and current[42]. Significant higher bone to implant contact has been reported as well as increased biomechanical removal torque values for phosphorous containing anodized surfaces compared to machined surfaces in dog and rabbit[43].

Laser modified micro- and nano-structured surface :

Laser is an emerging field for use as a micromachining tool to produce a 3-D structure at micrometer and nanometer level. The technique is a method of choice for complex surface geometries. The technique generates short pulses of light of single wavelength, providing energy focused on one spot. It is rapid, extremely clean, and suitable for the selective modification of surfaces and allows the generation of complex microstructures/ features with high resolution. These advantages make the technique interesting for geometrically complex biomedical implants. The Branemark BioHelix Implant has surface modified with laser micromachining process to create micro- and nano-structured surface roughness in only the inner part of the thread. The inner part of the thread is believed to be more suitable for bone formation than the outer part[44]. Short-term, experimental *in vivo* studies of laser-modified titanium implants with nanoscale surface topographical features have demonstrated a significant increase in removal torque and different fracture mechanisms [45].

Some surface reactive materials have shown the ability to form an interfacial chemical bond with surrounding tissues through a series of biophysical and biochemical reactions, causing ‘bioactive fixation’ of the implant[46].

Bioactive materials can be biostable (i.e. synthetic hydroxyapatite) or bioresorbable (i.e. bioactive glasses and glass-ceramics). Some bioactive ceramics like bioactive glasses of certain compositions have been claimed to have a real chemical bonding ability with soft tissues[47]. Calcium phosphate ceramics are integrated within bone following a well known sequence of events (Frayssinet, et al. 1993). They are considered to be bioactive and osteoconductive.

CONCLUSION

Primary stability and factors affecting

Factors	Influence on primary stability
Bone quality and quantity	
Cortical bone > trabecular bone	**Favorable**
	Favorable
Bone is post. Mandible > bone in posterior maxilla	
Bone in male > bone in female	
Implant characteristics	
-	**Favorable**
- Threaded > smooth surface	**More favorable**
- Tapered wide > non tapered	**More favorable**
- long implant	**Less Favorable**
- short implant	**More favorable**
- acid etched > mechanical surface	
- Acid etched +sandblasted > only acid etched	
Surgical technique	**Favorable**
-undersize drilling technique	**Favorable in low density**
-osteotome technique	**No different from conventional twist drill technique**
- piezosurgery	**Favorable**
	No effect
- flapless surgery	
- exposure to infrared wavelength	

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