An Overview Regarding Contemporary Biomechanical Aspects on Immediate Loading Dental Implants

José Mauricio dos Santos Nunes Reis, Lígia Antunes Pereira Pinelli,
Nicolau Conte Neto, Marcelo Silva Monnazzi
and José Cláudio Martins Segalla
UNESP - Univ Estadual Paulista / Araraquara Dental School
Brazil

1. Introduction

The use of dental implants for the treatment of partially or completely edentulous patients has become an effective therapy in the last years (Romeo et al., 2004). Therefore, the development of dental implants represents a remarkable advance in trends of Dentistry allowing to oral edentulous patients rehabilitation characterized by a high and long-term success.

Despite the great use of dental implants, many factors regarding its biomechanical aspects remain incompletely understood. According to Gross (2008), a preliminary consideration of the natural anatomy of the dentition, occlusion and alveolar support mechanisms would be helpful to provide a perspective for planning of implant supported restorations. Criteria as primary stabilization, bone quality, number, distribution, width, length and design of the dental implants, surface treatments, implant-abutment connection, and occlusion aspects must be also considered for the success of immediate, early or delayed loading dental implants (Casap et al., 2011).

In the delayed loading period, the implants are kept load free during the osseointegration period (varying from 3 to 6 months according to the insertion anatomic place and implant system requirements) and are rehabilitated afterward. In the early loading period, the rehabilitation of the implant is done during the first 3 months after the implantation, and according to Esposito et al. (2009), it is now recognized to generate harmful mechanical loading forces on the implants just at the time as the healing bone process has started and has not been finished yet.

In the immediate loading period, the waiting between implantation and loading is limited at a maximum of 48 hours, and the loading is only performed when good primary stability has been achieved. This procedure reduces the number of clinical steps and appears to allow a more comfortable and acceptable condition for the patients (Al-Omiri et al., 2005). Among the reasons for the immediate loading dental implants is the surgical trauma, which is minimized, in a one-step surgical procedure (Misch et al., 2004a). According to Misch et al. (2004a), the reduction of the surgical trauma in immediate loading procedures can be obtained by reducing heat during the surgical steps and reducing the stress on the bone-implant interface. The great advantage, besides avoiding a second surgical procedure, is the possibility to carry the dental implants (provisionalization) immediately after the surgery or some brief period after it (Misch et al., 2004a, 2004b). Several *in vitro* and *in vivo* studies have observed similar success between immediate and/or delayed loading implants (Attard & Zarb, 2005; Becker et al., 1997; Brånemark et al., 1999; Chiapasco et al., 2001; Chow et al., 2001; Degidi & Piattelli, 2003; Degidi & Piattelli, 2005; Ericsson et al., 1994; Gatti et al., 2000; Misch & Wang, 2003; Misch et al., 2004a, 2004b; Morton et al., 2004; Nkenke et al., 2005; Schnitman et al., 1997). However, in order to achieve success in immediate loading techniques its required a proper planning prior to implantation and considerable coordination among the oral surgeon, the prosthodontist and the laboratory. And it's thus required the exactly intraoperative transfer of the previously planned. Furthermore, the patient is very often required to wait many hours after the implant surgery for the completion of the immediate prosthetic work in the laboratory and it´s installation.

Based on the above information, the aim of this Chapter was to accomplish an overview regarding contemporary biomechanical aspects on immediate loading dental implants.

2. Primary stabilization

Primary stabilization is influenced by the surgical procedures, implants design and bone quality and quantity. After dental implant insertion, bone responds to the local stimulus, thus propitiating its repair through properties of bone plasticity, resorption and apposition. A bone remodelation begins on the bone-implant interface, accelerated by the low intensity loads, which induce the bone cells stimulation (Kenney & Richards, 1998). The patient's diet has a major importance during the bone apposition and remodelation after the immediate loading procedures. Consequently, soft diet should be indicated during the initial period (3 to 4 months) of the healing process and bone deposition (Misch et al., 2004a, 2004b). Most of the immature bone tissues formed is substituted by lamellar bone 3 to 6 months after the surgical placement of the implants in the delayed loading procedures (Duyck et al., 2001). Therefore, the immediate loading dental implants not only can reduce the risks of development of fibrous tissues, but also can minimize the development of immature bone, promoting a faster maturation of the immature bone to lamellar bone (Duyck et al., 2001; Zubery et al., 1999). Load transfer depends on successful osseointegration, which is characterized as a direct structural and functional connection between the bone and the implant surface (Adell et al., 1981; Brånemark et al., 1977). Thus, increasing the bone-implant contact surface area, directly related to implant diameter and length, can improve the osseointegration of implant to bone and establish implant stability. According to Misch et al. (2004a, 2004b), the smaller the applied stress to the bone, the smaller will be its micro-deformation and an increased surface area on the bone-implant interface will be expected. Short and long-term histological studies have demonstrated that immediate loading implants do not necessarily result in excessive stress on the bone-implant interface (Piattelli et al., 1993).

3. Bone quality and quantity

The close relationship between the bone and the implant is the core of osseointegration. Occlusal overloading on poor-quality bone can be a crucial factor in implant success and longevity. Different bone density may be observed for each region of the jaws. The posterior regions of the jaws usually have less dense bone than the anterior regions (Misch et al., 1999). Generally, the mandible has a denser and thicker cortical layer than the maxilla, with the cortical layer becoming thinner and more porous posteriorly. According to Morris et al. (2001), poor quality and quantity of surrounding bone was ranked as the most influential factor for reducing the success rate of dental implant treatments. Misch et al. (1999) stated that the density of the bone is directly proportional to the strength of the bone, with less density demonstrating strength reduction of 50% to 80% compared to higher density bone tissues. In addition, Goodacre et al. (2003) reported that dental implants loaded in lower density bone averaged 16% higher failure rates compared to more ideal bone quality. In a multicenter study by Weng et al. (2003), the posterior maxilla produced a 25% failure rate when short implants were used to support the prosthesis, and the implant failure occurred during the first 18 months of loading. Consequently, researchers have been unanimous for the indication of a larger number of implants for the rehabilitations of partially or completely edentulous maxillae. Therefore, the greater the number, the smaller will be the biomechanical risk. The design of the implants is more associated to the area of functional surface than to its size. Cylindrical implants without threads and with larger diameter possess smaller surface area in comparison to a screw implant of smaller diameter (Misch et al., 2004b). Consequently, implants with threads should be the most appropriate for the immediate loading procedures. This aspect will be focused in another section of this Chapter. Finally, following the recommendations of Attard & Zarb (2005), the posterior region of the jaws should be carefully evaluated for the indication of immediate loading implants. The cantilever elimination and the accomplishment of bilateral ferulization seem to be advantageous in order to reduce the stress concentrations on peri-implant bone.

4. Implant design

Several efforts have been focused to the knowledge and control of all factors that could enhance the osseointegration process, which includes those related to the implant design. The implant design refers to three-dimensional architecture of an implant system (Sykaras et al., 2000; Triplet et al., 2003), that is closely related to biological and biomechanical issues, especially those associated to the force transfer characteristics of implants (Geng et al., 2004; Siegele & Soltesz, 1989; Strong et al., 1998; Sykaras et al., 2000). Several aspects can be addressed in trends of implant design, but features related to the fixation shape, type of prosthetic interface and surface characteristics (surface topography and chemical composition) have been considerate the most important aspects within this context (Sykaras et al., 2000).

4.1 Dental implant shape

The Implant shape determines the surface area available for stress transfer and governs the initial stability of the fixation (Steigenga et al., 2003). Different kinds of implant shape designs have been described in the literature; however the root form implants have been dominating the implant market since it was developed. These dental implants are characterized by a body that works as a vertical bone column (Misch, 2008) and it can be presented as one or two-pieces implants (Jones & Cochran, 2006), solid or hollow, with a parallel, tapered/conical, or stepped shape/outline and a flat, round, or pointed apical end (Sykaras et al., 2000; Triplet et al., 2003).

4.1.1 Cylindrical vs tapered dental implants

Finite Element Analysis (FEA) and *in vivo* studies have demonstrated that taper implants are associated with advantages over cylindrical implants, including a greater initial stability (Lee et al., 2010) and the avoidance of "punching" stresses (Rieger et al., 1990). However, from a biomechanical perspective, studies have shown that cylindrical implants produced a more desirable stress profile than the conical shaped counterparts (Holmgren et al., 1998; Mailath et al., 1989; Siegele & Soltesz, 1989).

Within this context, recent studies have shown that in order to induce controlled compressive forces in the cortical bone layer during the implant insertion, a new hybrid self-tapping implant has been specifically designed for the use in critical quality bone, which combines the advantages of a conical implant with those of a cylindrical shape (Toyoshima et al., 2011).

4.1.2 One-piece vs two-pieces dental implants

Another category of implant design classify theses fixations as one-piece implant (non-submerged placement) which comprises the implant body and the soft tissue healing abutment manufactured as one piece, or two-pieces implants (submerged placement) that consist of an implant body and a separate abutment (Jones & Cochran, 2006). Regarding biomechanical issue, it was demonstrated that one and two-pieces implants have similar low force transmission characteristics under vertical loading (M.C. Cehreli et al., 2004) and since these stresses are extremely low, they do not seem to have any clinical relevance on the mechanical as well as the biomechanical outcomes (Pilliar et al., 1986; Szmukler-Moncler et al., 1998).

5. Dental implant prosthetic interface

The prosthetic interface represents the level in which the superstructure or the abutment connects to the implant body (Sykaras et al., 2000; Triplet et al., 2003). It is considered an important aspect of implant design since it can influence the force transmission mechanism by implant-prosthesis system (Bozkaya & Muftu, 2003; Geng et al., 2001) and the amount of bacterial invasion of the implant internal part (Tesmer et al., 2009). To date, both these factors are markedly implicated with the pathological bone loss around dental implants (Misch, 2008), which can compromise the maintenance of peri-implant aesthetic harmony or implant system stability.

The implant-abutment connection can be classified as external, which includes hexagonal, octagonal, and spline, with its interdigitating projections and slots, or internal that includes the morse-taper interface, the internal hexagon, and the internal octagon (Sykaras et al., 2000; Triplet et al., 2003). In general, morse-taper connections are associated with better outcomes regarding the maintenance of the peri-implant bone, since they have been associated with a lesser bacterial infiltration (Mangano et al., 2009) and a better force transmission mechanism by implant-prosthesis system (Merz et al., 2000), although other studies have found similar marginal bone levels and biological outcomes of different implant designs (Engquist et al., 2002; Heydenrijk et al., 2002).

As described previously, one limitation with the implant-suport rehabilitation relates to the marginal bone loss that still is seen in some implant systems. The probable factors are: a possible bacterial colonization located between implant and abutment (Goodacre et al., 2003) and/or a stress concentration at the neck of implants resulting from prosthesis overloading leading to bone microfractures. In an attempt to reduce this stress concentration in the bone-implant interface, the companies put on the market different types of connections attached to the prosthetic abutment. From a biomechanical perspective, the major distinction among implant systems is the implant-abutment connection. Mechanical failures, such as loosening and/or fracture of occlusal screws, abutment screws or abutments, are related to the type of implant-abutment connection (Akca et al., 2003). When it comes to biomechanics, an internal conical joint design is mechanically more stable than an external hexagonal or butt-joint implant-abutment connection, which improves the clinical outcome (Merz et al., 2000).

In another words, the type of connection is important because it directly interfere in the prosthetic restoration, and the restoration must receive and transmit the masticatory loads to the implants in a controlled manner to avoid mechanical and biological failure after the osseointegration. When inadequate tensions occur in the bone-implant interface, bone resorption may occur in incompatible levels with the maintenance of osseointegration. There are already some experimental, numerical, and clinical studies evaluating the influence of implant-abutment connection on osseointegrated implants (Pessoa et al., 2010). For Hebel & Gajjar (1997), the success of implant-supported restoration and the health of surrounding tissues are related to the accuracy and fit between the components, stability at implant-abutment interface, and the resistance of this interface submitted to masticatory loads (Hebel & Gajjar, 1997). The stability at implant-abutment interface may be influenced by several factors, such as, connection type (M. Cehreli et al., 2004) and retention system (Pellizzer et al., 2010).

5.1 External hexagon

The initial purpose of external hexagon implants was to transmit torque during surgical placement. Afterwards, the external hexagon was also shown to work as an antirotational mechanism and to orient the abutment in single tooth prostheses (Davi et al., 2008). The biomechanical complications reported are loosening or fracturing of the abutment and prostheses screws (Merz et al., 2000). Therefore, the external hexagon connection continues to be comprehensively used (Figures 1, 2 and 3) and studied with the aim of improving the dimensional machining tolerances of the components (Schulte, 1994), and making this screwed junction more stable.

The external hexagon system has advantages such as (a) suitable for the two stage method, (b) an anti-rotation mechanism and retrievability and (c) compatibility among different systems. Possible disadvantages of the external hex are: (a) micro-movements because of the size of the hex, (b) higher centre of rotation that leads to lower resistance for rotational and lateral movements and (c) a micro gap leading to bone resorption. However, the weak-link to the fixture of the external hexagon configuration, is often referred as a fail-self mechanism for over-loading situations (Maeda et al., 2006).

Davi et al. (2008) evaluated the integrity of the external hexagon of an implant system with internal and external hexagons but with prosthetic connection through the external hexagon (internal torque) in comparison with that of an implant system with external hexagon with mount (external hexagon). They concluded that the internal torque implant system may be preferable in clinical situations where implant placement within a certain bone density could generate torques higher than 60 N.cm. After application of an 80 N.cm torque, the external hexagon did not support the torque, suffering deformation of its external hexagon. According to the authors, the fragility of the external hexagon of some systems can compromise the future dental prosthesis if deformation of the hexagon vertices occurs due to the torque applied in the implant mount when the implant is placed. Greater rotation at the interface implant-abutment transfers stress to the implant components and to the bone, which could lead to screw loosening or fracturing, microfractures of bone, and loss of osseointegration.

Fig. 1. Buccal view of a 3i external hexagon dental implant after provisionalization and soft tissue conditioning

Fig. 2. Occlusal view of the 3i external hexagon dental implant

Fig. 3. Zirconia-based ceramic crowns after installation

5.2 Internal hexagon

One of the most important advances in the Implantology was the development of internal prosthetic connections, such as internal hexagon and morse-taper, in which excellent mechanical stability has been demonstrated *in vitro* (Merz et al., 2000). To ensure stability of the implants in long-term, science has turned its attention to improving the accuracy and passivity of prosthetic components, since it is unclear the level of mismatch between components that can affect the treatment success. Recently, some internal implant connections have appeared on the market, which are able to receive higher torques during surgical placement, with effective screw joint stability.

The internal hexagon system has advantages such as (a) ease in abutment connection, (b) suited for one stage implant installation, (c) higher stability and antirotation because of a wider area of connection and suited for single tooth restoration, (d) higher resistance to lateral loads because of the lower centre of rotation and (e) better force distribution; while its disadvantages are (a) thinner lateral fixture wall at the connecting part and (b) difficulty in adjusting divergences in angles between fixtures (Maeda et al., 2006).

From a biomechanical point of view, the design of the internal hexagon implant establishes a greater hexagon retention depth and the more precise and safer antirotational components of the internal hexagon system reducing the stress at the neck of the implant and retention screw (Hunt et al., 2005; Krennmair et al., 2002). In a study conduced by da Silva et al. (2010) evaluating the influence of connector and implant design on implant-tooth-connected prostheses, when the internal hexagon implant was assessed in the three types of connection (rigid connection, semirigid connection and rigid connection with oclusal screw), it was observed that the stresses on it occurred more in the apical region in comparison with the external hexagon, probably because of the greater depth of union of the denture to implant, and that the internal hexagon presented better stress dissipation characteristics than the external hexagon design. According to Krennmair et al. (2002), transferring the fulcrum point from the neck of the implant (external hexagon) to close to the middle third of the implant (internal hexagon), as well as the greater denture retention depth in the internal hexagon implant, reduced the power arm in the face of biomechanical behavior, making the implant more stable, with less tendency to screw loosening of fracturing, and improving the dissipations of tensions.

Bone resorption around the implant neck or cervical area may be explained by many other factors, however, smaller stress at cervical area of the internal hexagon system might contribute to the bone preservation, while larger stress at tip area might be one of the risk factors for bone resorption or fixture fracture (Maeda et al., 2006). Maeda et al. (2006), in an attempt to clarify the difference in the stress distribution patterns between implants with external or internal-hexagon connection systems using *in vitro* models, suggested that fixtures with internal-hexagon showed widely spread force distribution down to the fixture tip compared with external hexagon ones.

Pellizzer et al. (2010) evaluated the stress distribution of different retention systems (screwed or cemented) associated to different prosthetic connections (external hexagon, internal hexagon and morse-taper) in 3-unit implant-supported fixed partial prostheses through photoelasticity, and concluded that the internal hexagon implant was more favorable according to the biomechanical standpoint and also that the oblique load increased stress in all systems and connections tested. They believed that the stability at the implant-abutment interface, with internal connections, exhibits better contacts between the surfaces of abutment and implant, which decreases the micromovements during loading. In their study, among the internal connections, the morse-taper indicated better stress distribution.

5.2.1 Morse-taper

While high incidences of mechanical complications were reported for external-hexagon implants (Binon, 1996; Merz et al., 2000), insignificant episodes of abutment loosening were reported for solid-screw morse-taper implants (Levine et al., 1999). A different type of internal connection, known as morse-taper, was developed in an attempt to solve some biomechanical problems that still occur with internal hexagons implants. The implants have a conical union between implant and abutment, and this bond strength is proportional to the force used to insert. Tapered interference fits provide a reliable connection method between the abutment and the implant (Bozkaya & Muftu, 2003) and can also withstand prolonged lateral force applications (Merz et al., 2000). In the most common mechanical attachment method, a retaining-screw (abutment screw) is used to fix the abutment with respect to the implant. Another approach is to use a screw with a relatively large tapered end; the term taper integrated screwed-in (TIS) abutment is used to indicate an abutment, which uses simultaneously a screw and a tapered fit. A tapered interference fit (TIF) between the abutment and the implant is also used in some implant systems to provide the connection (Bozkaya & Muftu, 2005). For the systems using a screw, the connection between the implant and the abutment depends on the screw-preload, which is generated by applying a predetermined amount of torque during installation (Bozkaya & Muftu 2003). Designs in which the screw has a large tapered end essentially work like a tapered interference fit, and the screw threads do not appear to contribute to the connection; this mechanism relies on the large contact pressure and resulting frictional resistance, in the mating region of the implant–abutment interface, to provide a secure connection. In the morse-taper connection the bitting force acts in the direction of the abutment insertion, hence aids to secure the connection. This situation is in direct contrast to implants using screws where the biting force lowers the pretension in the screw (Bozkaya & Muftu, 2003).

Based on the previously information, it is clear that the morse-taper implant-abutment connection possesses higher mechanical behaviour than the external-hexagon (butt-joint) designs. In the external-hexagon implant design, the abutment screw alone is primarily responsible for maintaining the implant-abutment complex assembly under functional loads (Akca et al., 2003). Therefore, the axial preload of the abutment screw is a determining factor for the stability of the connection (Burguete et al., 1994). However, in the morse-taper connection, lateral loading is resisted mainly by the tapered design, which prevents the abutment from tilting (Akca et al., 2003). Because of the tapered design, a high normal pressure is maintained in the contact area, allowing stable retention of position by frictional forces (Merz et al., 2000). Taper joint connections with a conical seal, or Morse's taper, have advantages of better sealing capabilities in closing the micro-gap on top of those in an internal hexagon system (Maeda et al., 2006).

Regarding immediately loading implants, it was demonstrated that the implant-abutment connection design did not significantly influence the bone strain and the implant displacement. On the other hand, the Morse-taper connection presented superior abutment stability and the least stress concentration in the abutment screw, and the internal hexagon and external hexagon implants presented the lowest strain levels (Pessoa et al., 2010). Pieri et al. (2011) compared the clinical and radiographic outcomes of single implants immediately placed and restored with two different implant-abutment connections, prosthetic abutments with a Morse-taper connection and a platform switch (test group), and conventional abutments with an internal connection and a matching diameter (control group). No statistical significant differences were found between the two groups for periodontal parameters, marginal soft tissue level change, or papilla height, but greater marginal bone loss was observed at the control sites compared to the test sites. Although the control group demonstrated a slight increase in marginal bone loss compared to the test group, the peri-implant soft tissues were very stable with both types of implant-abutment connection after 12 months of loading.

5.3 Platform switching

According to Serrano-Sánchez et al. (2011), the platform switching effect was accidentally established in the 1980s and early 1990s when different dental implant manufacturers introduced implants of larger diameter before producing the corresponding abutments of the same measures. Thus, it involves reducing the abutment diameter in comparison with the diameter of the dental implant. Sánchez reported that it is possible to use abutments with a diameter smaller than the implant body width, or alternatively an implant design can be used in which the neck diameter is increased with respect to the implant body width, like suggested by Calvo-Guirado et al. (2009). The contemporary literature is unanimous in affirm that the use of platform switching dental implants improves bone crest preservation, contributes to biological space reposition, and, therefore, is directly related to excellent aesthetic outcomes. Conversely, Sabet et al. (2009) reported that the platform switching should be not used in mandibular implant-mucosal support prostheses, since reduction of the diameter of the junction lessens the abutment resistance in response to occlusal loading applied in the posterior area of the overdentures.

6. Surface characteristics

The surface characteristics have been considerate by Albrektsson et al. (1981) as relevant factors that could influence the establishment of a reliable osseointegration. In fact, it was demonstrated that the surface properties could influence the healing dynamics around bone-interfacing implants (Lee et al., 2008). Within this context, topographic and chemical properties have been considerate the most relevant features related to surface characteristics since they play a major role in the biological events that follow implantation (Le Guéhennec et al., 2007).

6.1 Topographic properties

According to Stanford (2008) the evaluation of an implant surface refers to macroscopic and microscopic features that, when combined, are used to describe the surface topography, being considered a relevant issue, since it can produce orientation and guide locomotion of specific cell types and has the ability to directly affect cell shape and cell function (Brunette & Chehroudi, 1999; Chou et al., 1998; Qu et al., 1996).

6.1.1 Macroarchitecture

The main characteristics regarding the macroarchitecture include the presence or absence of threads as well its design which are considered important factors that could affects the osseointegration process (Vidyasagar & Apse, 2004), because they play an important role in load transfer from dental implant to the surrounding bone (Schenk & Buser, 1998), affecting the stress distribution and marginal bone resorption (Chun et al., 2002). Furthermore, threads are used to maximize the initial contact, improve stability (Sykaras et al., 2000; Triplet et al., 2003) and enlarge the implant surface area (Kong et al., 2008). According to Misch et al. (2006), the greater the number of threads, the greater will be the surface area, if all other factors are equal. On the other hand, the thread number may be more significant for the shorter implant in the posterior regions of the mouth with reduced bone density. Regarding thread design, a sort of varying geometric pattern that determine the functional thread surface can be found relating to thread depth, thread pitch, thread helix angle, thread thickness and thread face angle (Misch, 2008). These two last geometric aspects determine the shape of the thread, which can be V-shape, reverse buttress or a square thread (Strong et al., 1998; Thakur, 1997) and this last one is associated to the highest contact area (Lee et al., 2008).

6.1.2 Microarchitecture

The surface microarchitecture of dental implants refers to the classification of the implant design based on the average surface roughness (Sa). According to Triplet et al. (2003) most of the papers have described the dental implants surface as smooth (Sa ≤ 1.0 μm) or rough (Sa > 1.0 μm), although other terms, such as porous, minimally rough (0.5–l.0 μm), intermediately rough (1–2.0 μm), and rough (2–3.0 μm) have also been proposed (Wennerberg et al., 1995).

a. Smooth surfaces

The original Brånemark implant (Nobel Biocare, Göteborg, Sweden) is a turned screw of minimal surface roughness (Sa between 0.5 and 1.0 μm) that represents the main example for smooth surfaces. Nowadays, these surfaces have not been indicated yet, since they are associated with several disadvantages, including: slower biological processes at the bone–implant interface (BIC) (Elias et al., 2008), poor mechanical integration with bone, since these surfaces provide no resistance to mechanical forces at the BIC, allowing epithelial down growth and are associated with deeper peri-implant pockets (Puleo, 2006).

b. Rough surfaces

The development of rough implant surfaces represents a great advance to solve the problems of smooth surfaces. In fact, rough surfaces typically result in better clinical outcomes, probably due to the advantages offered by these superficies, such as lesser crestal bone loss (Wiskott & Belser, 1999), faster rate and higher degree of bone formation (Abrahamsson et al., 2004), higher percentage of contact at the BIC (Suzuki et al., 1997), increased surface energy, improves matrix protein adsorption, bone cell migration and proliferation, and finally osseointegration (Dohan Ehrenfest et al., 2009).

On the other hand, surface roughness may lead to negative consequences due to the changes on surface microcomposition (M. Cehreli et al., 2004), such as increased risk of peri-implantitis, especially in high surface roughness (Albrektsson & Wennerberg, 2004), since rough surfaces acts in favor to plaque accumulation (van Steenberghe et al., 1999) and increased risk of ionic leakage, since greater surface roughness gives greater tissue-implant contact and hence ionic leakage (Albrektsson & Wennerberg, 2004).

The main clinical indication for using an implant with a rough surface includes areas with poor quality or volume of the host bone, since in these unfavorable clinical situations early and high bone-to-implant contact would be beneficial for allowing high levels of loading (Conner et al., 2003; Testori et al., 2001).

c. Porous surfaces

Some papers have described the Porous surface, which represents those with an extremely high Sa. These surfaces are characterized by pore size, pore shape, pore volume, pore depth and different from the rough surfaces due to the lack of sharp edges (Sykaras et al., 2000). It is evident that bone ingrowth into porous implant surfaces may result in improved osseointegration and mechanical stability by interlocking the surrounding bone tissue with the implant (Götz et al., 2004). These surfaces are produced when spherical powders of metallic or ceramic material become a coherent mass with the metallic core of the implant body (Sykaras et al., 2000, Triplet et al., 2003), being affected by the size of spherical particles, temperature and pressure conditions of the sintering chamber (Esposito et al., 1998).

6.2 Physicochemical properties

These properties usually refer to factors such as surface energy, charge and composition of the titanium implants (Albrektsson & Wennerberg, 2004; Puleo, 2006). These characteristics differ, depending on their bulk composition and surface treatments; affecting biological process including the protein adsorption and cell attachment (Le Guéhennec et al., 2007), as well largely determines the chemical stability/reactivity (Kasemo & Lausma, 1988).

The surface energy is a relevant issue, since affects directly the hydrophilicity of the surface. It is well know that highly hydrophilic surfaces (higher surface energy) seem more desirable than hydrophobic ones in view of their interactions with biological fluids, cells and tissues (Buser et al., 2004; Zhao et al., 2005).

7. Methods of surface modification

In order to improve the osseointegration of titanium dental implants, clinical efforts have been done to develop methods to provide an enhanced osseous stability through microsurface mediated events (Stanford, 2008) by the micro and nanoscale modifications of dental implant surface roughness and chemistry.

With surface treatment, it is possible to change the surface features of the titanium dental implant, such as chemical composition, energy level, morphology, topography and roughness (Upp et al., 2006). To date, several methods used to increase roughness, frequently tend to change the surface chemistry as well as texture (Puleo, 2006), such as Alkali and heat treatments (Lee et al., 2002).

For didactic reasons, only the main methods usually employed to modify surface properties will be discussed in detail in this Chapter and they can be classified as ablative (remove material from the surface) or additive (deposit material on implant surfaces) (M. Cehreli et al., 2004; Puleo, 2006).

7.1 Ablative methods

a. Grit blasting

This method consists in blasting the implants with hard ceramic particles, resulting in different surface roughnesses according to the ceramic particles sizes, time of blasting, pressure and distance from the source of particles to the implant surface (Sykaras et al., 2000; Triplet et al., 2003). Several ceramic particles have been used, such as alumina, titanium oxide and calcium phosphate particles (Le Guéhennec et al., 2007).

b. Acid etching

In this method the metallic implant is immersed into an acidic solution such as HCl, H_2SO_4, HNO_3 and HF (Le Guéhennec et al., 2007) which erodes the implant surface, creating pits of specific dimensions and shape that vary according to the concentration of the acidic solution, time, and temperature (Sykaras et al., 2000). Through acid etching it is possible to control the roughness, number, size and porous distribution on micrometer and nanometer scales (Elias et al., 2008).

c. Grit blasting followed by acid etching

This surface was produced by blasting implants with 250 to 500 mm corundum grit followed by acid etching in a hot solution of hydrochloric acid and sulfuric acid (Puleo, 2006) that have been developed by Institute Straumann (Basel, Switzerland) (Buser et al., 1998). Sandblasting produces macro-roughness onto which acid etching superimposes micro-roughness (Cochran et al., 1998).

7.2 Additive methods

a. Plasma-spraying

Plasma spray coating is one of the most common methods for surface modification. This method consists in injecting both Ti or HA powders into plasma torch at high temperature (Le Guéhennec et al., 2007). Thickness depends on particle size, speed and time of impact, temperature, and distance from the nozzle tip to the implant surface area (Sykaras et al., 2000, Triplet et al., 2003).

It is relevant to state that by coating implants with hydroxyapatite (HA) both the roughness and surface chemistry are altered, resulting in an increased roughness with a dramatically change in surface chemistry from TiO_2 to a bone-like ceramic with the potential to chemically bonding to bone (Puleo, 2006). Furthermore, beyond plasma spray coating, other methods have been developed to coat metal implants, such as sputter-deposition, sol–gel coating, electrophoretic deposition or biomimetic precipitation (Le Guéhennec et al., 2007).

b. Anodization

This method produces modifications in the microstructure and the crystallinity of the titanium oxide layer (Sul et al., 2002) (Figures 4 to 9). It consists of preparing a porous oxide surface by potentiostatic or galvanostatic anodization of titanium in strong acids (H_2SO_4, H_3PO_4, HNO_3, HF) at high current density (200 A/m^2) or potential (100 V) (Le Guéhennec et al., 2007). The properties (thickness, microstructure, composition) of the oxide will depend on different process parameters such as electrolyte composition, anodic potential, current, temperature, and electrode geometry (Triplet et al., 2003).

Fig. 4. Preoperative clinical aspect of the edentulous space

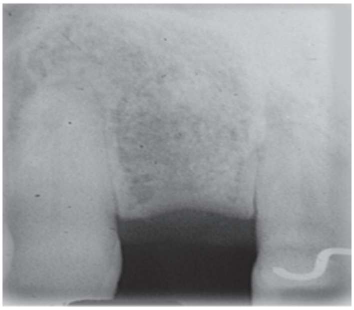


Fig. 5. Preoperative periapical radiographic

Fig. 6. Surgical approach to the alveolar bone

Fig. 7. Nobel Replace Select dental implant being positioned

Fig. 8. Postoperative clinical aspect of the final prosthesis

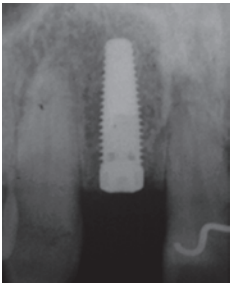


Fig. 9. Postoperative radiographic aspect of the dental implant

7.3 Incorporation of biologically active drugs into titanium dental implants

Modern trends associated with dental surface modification include the incorporation of several growth and differentiation factors either alone or combined as biocoatings of conventional implants. These factors include the bone morphogenetic proteins (BMPs), in particular BMP-2 and BMP-7 or osteogenic protein-1 (OP-1), and growth factors such as platelet-derived growth factor (PDGF), insulin-like growth factor (IGF), and transforming growth factor-beta 1 (TGF,-1) alone or combined with IGF-1, and TGF (Mavrogenis et al., 2009).

Other biological coatings that have been used to improve osseointegration of titanium implants include collagen and other extracellular matrix proteins such as fibronectin and vitronectin (Ku et al., 2005), and systemic administration of pharmacological agents such as ibandronate and human parathyroid hormone (Dayer et al., 2010).

8. Short implants

In a multicenter retrospective 6-year case series study, Misch et al. (2006) stated that there are three risk factors that increase stress and may explain why posterior short implants may have a higher failure rate compared to longer implants in the literature: 1) an increased crown height, 2) higher bite forces, and 3) bone density in the region. An increased crown height results in a vertical cantilever (Figure 10), in which the load transfer to the implant may be increased by 100% (Bidez et al., 1992). In order to reduce the stress at bone-implant interface the authors included 1) no cantilevers on the prostheses, 2) no angled forces to the posterior restorations, and 3) splinting multiple implants together. Splinted implants increase functional surface area of support whenever a load is applied to the prosthesis (Bidez et al., 1992). In addition, eliminating lateral contacts in mandibular excursions and cantilevers on the prosthesis helps to reduce forces on the implants. Increasing the implant number and splinting multiple implants in the prosthesis result in more functional area, in which the forces are applied and transferred. According to Gross (2008) studies after 1997 taking into account bone density and surface finish with microtexture versus machined co-variables, report comparable survival rates for short and standard length implants. These observations are corroborated by the study of Misch et al. (2006), in which, through employing properties of biomechanical stress reduction, high implant success rates in short implants of 7.0 and 9.0 mm can be predictably attained as reported in this and other studies.

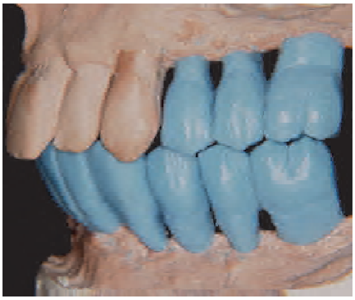


Fig. 10. Set-up wax of increased crowns height resulting in a vertical cantilever. Splinting must be considered

9. Guided dental implant surgery

Many methods to speed up the prosthetic stage have been devised in which devices could guide the surgeon on the implants placement, such as the Ohio State University Framework (Turkyilmaz et al., 2009) or the Novum System (Nobel Biocare, Göteborg, Sweden). However, these methods have not completely succeed because they solve a limited number of immediate planned loading cases because the failure in to feet individual anatomic variation.

The previous planning includes the patient complete anamnesis, the extra and intraoral examination in order to verify all anatomic and aesthetics components that are missing or should be improved. During the planning period conventional two-dimensional radiographs are necessary to evaluated available bone and the relationship between the implant insertion area and relevant anatomic structures, such as the inferior alveolar nerve and the maxillary sinus, and some templates representing the prosthetic setup could be made over these radiographs. However, this kind of preoperative planning neglects information about the third dimension of the patient´s anatomy.

Computer tomography has been providing medicine with some kind of three-dimensional anatomic information for at least thirty years, although for dentistry it was restricted to selected cases. At the last years the increasing availability, reduced radiation and lower costs of 3-D (three dimensional) imaging exams thanks to cone bean computer tomography development the 3-D implant planning is becoming more often used in dentistry and maxillo-facial surgery (Schneider et al., 2009). In conjunction with the 3-D tomography several manufactures developed computer software allowing virtual implant placement using the acquired digital data from the computed tomography (CT) scan (Mandelaris et al., 2010).

The transfer of the previously planned at the computer software according to the 3-D anatomic data scanned of the patients face, can be done by the use of stereolithographicsurgical guides created by computer-aided design and computer-aided manufacturing (CAD-CAM) technology or by "navigation" systems that use intra-operative optical tracking of the hand-piece position and guide the surgeon in real-time during the surgery providing visual feedback on a screen. The first one described is the more often used due to the inferior costs and because the high technology development required to use "navigations" systems are not available everywhere. Computer-aided implantation minimizes the error in implant positioning compared to conventional surgical guide implant placement and allows the provisory restoration to be manufactured prior to surgery (Yamada et al., 2011). Thereafter even the CAD-CAM technology provide the surgeon very precise information about the anatomy and the correct placement of the implants, so precise that allows the surgeon to perform flapless surgeries (Barnea et al., 2010; Patel, 2010).

The flapless surgery for placement of dental implants has some advantages such as the maintenance of the periosteum attachment and blood supply to the bone, avoids gingival profile modification following the contour of the surgical incision, reduces the postoperative edema, bleeding, pain and discomfort for the patients and clearly make the surgical time shorter (Abad-Gallegos et al., 2010; Azari & Nikzad, 2008). These advantages seem to increase the success rates of immediate loading, probably due to the blood supply preservation (Fortin et al., 2003; Malo et al., 2007). The flapless surgery is only possible with the use of surgical guides that should be precisely made; with this methodology it is always possible to avoid inadequate positioning of the implant and the unintentionally anatomic structures contact with the implant surface. Remembering always that in this kind of surgery both the safety and success of treatment depend on the surgeon and prosthodontist accuracy. But despite many benefits described about the flapless implantation, this type of procedure could be perceived as a blind procedure due to the difficulty in evaluation alveolar bone contours and fenestrations or different angulations, setbacks that increases the chances of cortical plates perforation or fenestration when performed unassociated to the guided planning, however, the new 3-D computer guided planning technology made the implant insertion so precise that the setbacks of the flapless surgery were almost all vanished.

Some protocols for rehabilitation of completely edentulous jaws with flapless surgery and the placement of immediate fixed prostheses through computer guided surgery seems to be effective and predictable according to Puig (2010), besides with high potential for the patients acceptance, however, the author states that this techniques, for example the "all-on-four" and "all-on-six" protocols, could be sensitive to the experience of the surgeon and like all other surgical techniques its requires a learning curve from the surgeons who intend to perform they.

However, complications may occur during computer-guided surgery and the superstructure, sometimes, cannot be inserted immediately. Complications like insufficient primary implant stability or misfit of the restoration due to transfer mistakes, mistakes that can be justified due the mucosa anatomic alterations in flapless surgeries, unstable fixation of the surgical guide, imprecise impressions and incorrect pouring of the casts. Also the incorrect acquisition of tomographic image and processing could lead to errors (Almeida et al., 2010). Because of this some potentially complications, some author do recommend the application of guided surgery with flapless approach in cases with adequate bone volume and states that the guided technique can also be used in sites with insufficient bone volume, but a mucoperiosteal flap procedure is recommended (Fitzgerald et al., 2010).

The guided surgery has been indicated for complete and partial edentulism, for booth maxilla and mandibular bones. Thus many authors agree that the mainly advantage of this method is the use in the maxilla because of its anatomic peculiarities (Meloni et al., 2010; Vasak et al., 2011). Jung et al. (2009) revealed, after a systematic review including 29 different image guidance systems, a high mean implant survival rate of 96.6% after only 12 months of observation in different clinical indications.

There is no doubt that the computer guided surgery is a very advanced treatment and it's belong to the future of the implant treatment, although it seems to be a safe and predictable treatment, future long-term clinical data are necessary to identify the right clinical indications and to justify additional radiation doses, efforts and costs associated with this technique; because until now, despite all described advantages there is no evidence to suggest that computer guided surgery is superior to conventional procedures in terms of safety, outcomes, morbidity or yet success rates.

9.1 Surgical and prosthetic sequence

The virtual planning was first executed over the images acquired with the computerized tomography of the patient (Figures 11, 12 and 13), planning the implants position according to the desired teeth future positioning and to the existing bone support.

Afterwards the implant´s company makes the surgical guide based on the previous virtual planning done by the surgeon using the specific software that this company supplies for the surgeons (Figure 14).

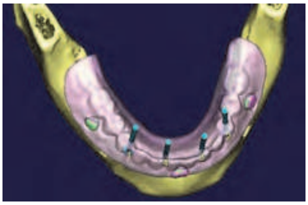


Fig. 11. Virtual planning occlusal view

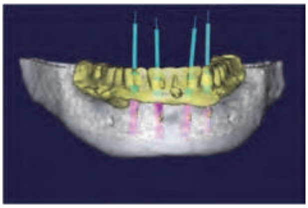


Fig. 12. Virtual planning frontal view

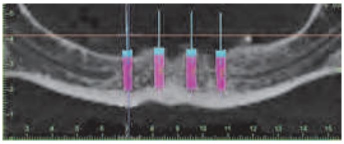


Fig. 13. Virtual planning on the panoramic view of the computerized tomography

Fig. 14. Surgical guide made by the implant system company

The preoperative frontal view of the patient's mouth can be seen in Figure 15. With the surgical guide in hands the surgeons shall performs the surgery, after the anesthetization the surgeons most secure the surgical guide by drilling three or four holes at the exactly spots and locking the guide with the proper devices (Figure 16).

After locking the surgical guide starts the drilling steps, following the exactly drill sequence designed by the implant company in order to make the implant insertion with the same inclinations that previously virtually planned (Figure 17). The implants were inserted by flapless surgery guided through the surgical guide (Figure 18). After the complete insertion, the prothetical abutments are locked over the implants (Figure 19) and the total prosthesis was installed (Figure 20).

Fig. 15. Preoperative patient´s mouth view

Fig. 16. Surgical guide in place and locked

Fig. 17. Drilling steps according to the manufacturer´s orientation

Fig. 18. Implants insertion completed

Fig. 19. Removal of the surgical guide and abutment insertion

Fig. 20. Clinical case completed with the total inferior prosthesis installation in less than 24 hours (Courtesy of Prof. Dr. Valfrido Pereira Antonio Filho)

10. Occlusion aspects

Although the etiological factors underlying bone loss have not been fully established (Prosper et al., 2009), Canay & Akça (2009) stated that the main contributory factors of bone loss are occlusal overload and peri-implantitis. Current concepts are mixed regarding the peri-implant response to occlusal overload. Gross (2008) reported that a phenomenon of fatigue microtrauma has been proposed as the process of cervical and progressive bone loss as bone ‘’modeling’’ due to excessive occlusal load. When the rate of fatigue microdamage exceeds the reparative rate, cervical bone is irreversibly lost. According to Kozlovsky et al. (2007), the overloading aggravated plaque-induced bone resorption, and increased bone loss of the dental implants. The decreasing of the functional surface of the dental crowns, the loads being directed to the long axis of the implants, the provisionalization and an adequate occlusal adjustment seem to favor the immediate loading implants result. In addition to poor bone quality, unfavorable force direction and concentration may increase failure rates of implants (Becktor et al., 2002; Chen et al., 2008). The question of splinting is also relevant to a discussion of occlusion as previously described. Some authors (Nokar et al., 2010; Zarone et al., 2003) advocated separation of mandibular superstructures in the midline (Figures 21 to 24) and cite mandibular flexure as a potential source of distal implant morbidity in full-arch restorations. However, additional studies about bone loss and prosthesis failure are necessary to confirm these findings.

Fig. 21. Initial clinical aspect

Gross (2008) suggested that the occlusion should be viewed as consisting of three basic elements: posterior support, occlusal vertical dimension (Figure 25) and eccentric or anterior guidance. The degree of vertical and horizontal overlap determines whether the anterior teeth disclude the posterior teeth in protrusion and whether the working side discludes the non-working side in latero-protrusive movements (anterior disclusion). Mutual protection is directly dependent on posterior support, in which the molars protect the anterior teeth during occlusion and the anterior teeth protect the posteriors in excursive movements. Gross also recommends to avoid creation of excursive guidance on single implant

Fig. 22. Cast after the impression of immediate placed dental implants

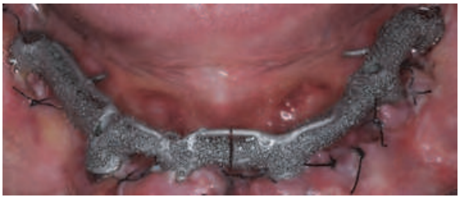


Fig. 23. Bar casted in two rigid segments, with a minimum separation in the anterior region

Fig. 24. Final aspect of the oral rehabilitation

restorations in order to prevent overloading to the prosthesis, abutment, implant and, therefore, to bone-implant interface. Cantilevers must be also avoided (Figure 26) or decreased (Figure 27) when possible. It must be remembered that the greater the bucco-lingual (Figure 28), mesial, distal or vertical cantilever, the greater will be the biomechanical failure risk. Finally, the decreasing of the functional surface of the crowns, the loads being directed to the long axis of the implants, the absence of cantilevers during the provisionalization and an adequate occlusal adjustment seem to favor the immediate loading implants results (Misch & Bidez, 1995).

Fig. 25. Occlusion vertical dimension determined by a Lucia’s Jaw Interference Guide (JIG)

Fig. 26. Total implant-supported prosthesis with no cantilever

Fig. 27. Shortened dental arch concept reducing the length of the cantilever by using one premolar for each quadrant

Fig. 28. Unsatisfactory implant-supported prosthesis. See the great bucco-lingual cantilever and the inadequate orientation of the teeth

11. Ferulization

A key factor for success or failure of dental implants is the manner in which stresses are transferred to bone-implant interface (Geng et al., 2001). Finite Element Analysis (FEA) is a useful tool for the determination of stresses and displacements in mechanical objects and materials, but is also frequently used in biological systems like in dentistry. Bevilacqua et al. (2008) reported that stress at the bone-implant interface increased with increasing single implant inclinations. Therefore, these authors demonstrated that vertical implants remain the first choice for single implants, given that stress transmitted to the bone-implant interface increases with increasing implant inclinations. On the other hand, different results were found in another study made by Bevilacqua et al. (2011), regarding the stress distribution in maxillary implant-supported fixed dentures, in which tilted implants were used in fixed denture designs. In this study, tilted distal implants, rigidly splinted, decreased peri-implant bone stresses as compared to a vertical implant model with cantilevered segments. From the results of this investigation the authors concluded that the use of distal tilted implants results in a reduction in stresses in the peri-implant bone and in metal frameworks secondary to cantilever length reduction and implant length increase. Therefore, the concept of splinted arch seems to be very pertinent when immediate loading procedures are indicated for patients with extensive implant-supported prostheses and for edentulous patients. In addition, it seems to be quite evident the use of a larger number of implants and their splinting (if possible) when one-step surgical procedures are indicated (Attard & Zarb, 2005).

12. Parafunctional habits

Another relevant aspect that must be taken into account is the presence of parafunctional habits. Parafunctional habits may generate overloading and may contribute with up to 75% of the immediate loading implants failure. These non-functional habits may increase the looseness or fracture risk of the abutments and of the restorations (Mish et al., 2004b). According to Gross (2008), eccentric occlusal parafunction may generate extremely high and potentially destructive loads, sufficient to wear down the teeth, fracture crowns and roots, decement or break fixed partial dentures, dislodge or break abutment screws, fracture porcelain or superstructures, traumatize supporting bone and break implants. Thus, bruxism should be diagnosed and addressed as a complicating and additional risk factor. In agreement with some authors (Colomina, 2001; Misch et al., 2004a), when the parafunctional habits are not normalized, its presence may be an exclusion criterion for the immediate loading dental implants. Regardless the procedure (immediate, early or delayed) for the dental implants and prosthesis insertion, the use of a full-arch night splint may be beneficial in reducing potential overload from nocturnal parafunction. Despite the fact that some reviews show that bruxism has not been causally linked to supporting bone morbidity, its potential for creating complication in the superstructure and implant stack are very real (Gross, 2008).

Parafunction is a significant factor in the planning of excursive guidance and the creation of an occlusal scheme with abutment and bone support optimally designed to minimize the potentially destructive forces of bruxism (Gross, 2008). Therefore, flattening guiding inclines, increasing implant numbers and bone support, splinting multiple implants together, reducing occlusal vertical dimension to decrease crown-root ratio and minimizing functional occlusal surfaces and cupids without excessively compromising tooth shape should be also considered.

13. Conclusions

Physical and biomechanical procedures, such as splinting and appropriate occlusal adjustment, must be always followed in order to avoid the overloading risks and the stress on bone-implant interface.

Short implants, cantilevered segments and external hexagon connections may be associated with increased problems such as screw loosening, as well as screw, denture teeth, denture base, and framework fractures.

The treated surface dental implants and morse-taper implant-abutment connection possesses higher biomechanical behavior than the non-treated dental implants, and the conventional external and internal hexagon designs, respectively

Restorations should be planned on an articulator with a diagnostic wax set-up, and radiographic and surgical guides used when possible and necessary.

Computerized guidance systems may improve the accuracy of surgical procedures, especially in clinical situations in which the bone ridge and the anatomical relations are unfavorable.

14. Acknowledgments

We would like to thanks Prof. Dr. João Gustavo Rabelo Ribeiro, Prof. Dr. Marcelo Antonialli Del'Acqua, Prof. Dr. Valfrido Antonio Pereira Filho, Prof. Dr. Leandro Eduardo Kluppel and Ricardo Pasquini Filho for the courtesy of some clinical Figures.

15. References

Abad-Gallegos, M.; Gómez-Santos, L.; Sánchez-Garcés, M.A.; Piñera-Penalva, M.; Freixes-Gil, J.; Castro-García, A. & Gay-Escoda, C. (2010). Complications of guided surgery and immediate loading in oral implantology: a report of 12 cases. *Medicina Oral Patologia Oral y Cirurgia Bucal,* Vol.15, (August 2010), (Epub ahead of print), ISSN 1698-6946

Abrahamsson, I.; Berglundh, T.; Linder, E.; Lang, N.P. & Lindhe, J. (2004). Early bone formation adjacent to rough and turned endosseous implant surfaces. An experimental study in the dog. *Clinical Oral Implants Research*, Vol.15, No.4, (August 2004), pp. 381–392, ISSN 0905-7161

Adell, U.; Lekholm, U.; Rockler, B. & Brånemark, P.I. (1981). A 15-year study of osseointegrated implants in the treatment of endentulous jaw. *International Journal of Oral Surgery,* Vol.10, No.6, (December 1981), pp. 387-416, ISSN 0300-9785

Akca, K.; Cehreli, M.C. & Iplikcioglu, H. (2003). Evaluation of the mechanical characteristics of the implant-abutment complex of a reduced-diameter morse-taper implant. A nonlinear finite element stress analysis. *Clinical Oral Implants Research,* Vol.14, No.4, pp. 444-454. ISSN 0905-7161

Albrektsson, T.; Brånemark, P.I.; Hansson, H.A. & Lindstrom, J. (1981). Osseointegrated titanium implant. Requirements for long lasting, direct bone-to-implant anchorage in man. *Acta Orthopaedica Scandinavica*, Vol.52, No.2, pp. 155–170, ISSN 0001-6470

Albrektsson, T. & Wennerberg, A. (2004). Oral Implant Surfaces: Part 1—Review Focusing on Topographic and Chemical Properties of Different Surfaces and In Vivo Responses to them. *The International Journal of Prosthodontics,* Vol.17, No.5, (September-October 2004), pp. 536–543, ISSN 0893-2174

Almeida, E.O.; Pellizer, E.P.; Goiatto, M.C.; Margonar, R.; Rocha, E.P.; Freitas-Jr, A.C. & Anchieta, R.B. (2010). Computer-guided surgery in implantology: Review of basic concepts. *The Journal of Craniofacial Surgery,* Vol.21, No. 6, (November 2010), pp. 1917-1921, ISSN 1049-2275

Al-Omiri M.; Hantash R.A. & Al-Wahadni A. (2005). Satisfaction with dental implants: a literature review. *Implant Dentistry*, Vol.14, No.4, (December 2005), pp. 399-406, ISSN 1056-6163

Attard N.J. & Zarb G.A. (2005). Immediate and early implant loading protocols: a literature review of clinical studies. *The Journal of Prosthetic Dentistry*, Vol.94, No.3, (September 2005), pp. 242-58, ISSN 0022-3913

Azari, A. & Nikzad, S. (2008). Flapless implant surgery: review of the literature and report of 2 cases with computer-guided surgical approach. *Journal of Oral and Maxillofacial Surgery,* Vol.66, No.5, (May 2008), pp. 1015-1021, ISSN 0278-2391

Barnea, E.; Alt, I.; Kolerman, R. & Nissan, J. (2010). Accuracy of a laboratory-based computer implant guiding system. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology Endodonty,* Vol.109, No.5, (May 2010), pp. e6-e10, ISSN 1079-2104

Becker, W.; Becker, B.E.; Israelson, H.; Lucchini, J.P.; Handelsman, M.; Ammons, W.; Rosenberg, E.; Rose, L.; Tucker, L.M. & Lekholm, U. (1997). One-step surgical placement of Brånemark implants: a prospective multicenter clinical study. *The International Journal of Oral & Maxillofacial Implants*. Vol.12, No.4, (July-August 1997), pp. 454-62, ISSN 0882-2786

Becktor, J.P.; Eckert, S.E.; Isaksson, S. & Keller, E.E. (2002). The influence of mandibular dentition on implant failures in bone-grafted edentulous maxillae. *The International Journal of Oral & Maxillofacial Implants*, Vol. 17, No.1, (January-February 2002), pp. 69-77, ISSN 0882-2786

Bevilacqua, M.; Tealdo, T.; Menini, M.; Pera, F.; Mossolov, A.; Drago, C. & Pera, P. (2008). Three-dimensional finite element analysis of load transmission using different implant inclinations and cantilever lengths. *The International Journal of Prosthodontics,* Vol.21, No.6, (November-December 2008), pp. 539-42, ISSN 0893-2174

Bevilacqua, M.; Tealdo, T.; Menini, M.; Pera, F.; Mossolov, A.; Drago, C. & Pera P. (2011). The influence of cantilever length and implant inclination on stress distribution in maxillary implant-supported fixed dentures. *The Journal of Prosthetic* Dentistry, Vol.105, No.1, (January 2011), pp. 5-13, ISSN 1097-6841

Bidez, M.W. & Misch, C.E. (1992). Force transfer in implant dentistry: Basic concepts and principles. *Journal of Oral Implantology*, Vol.18, No.3, pp. 264-274. ISSN 0160-6972

Binon, P.P. (1996) The effect of implant/abutment hexagonal misfit on screw joint stability. *The International Journal of Prosthodontics,* Vol.9, No.2, (March-April 1996), pp. 149-160, ISSN 0893-2174

Bozkaya, D. & Muftu, S. (2003). Mechanics of the tapered interference fit in dental implants. *Journal of Biomechanics*, Vol.36, No.11 (November 2003), pp. 1649–1658, ISSN 0021-9290

Bozkaya, D. & Muftu, S. (2005) Mechanics of the taper integrated screwed-in (tis) abutments used in dental implants. *Journal of Biomechanics,* Vol.38, No.1 (January 2005), pp. 87-97, ISSN 0021-9290

Brånemark, P.I.; Hansson, B.O.; Adell, R.; Breine, U.; Lindström, J.; Hallén, O. & Ohman A. (1977). Osseointegrated implants in the treatment of the endentulous jaw. Experience from a 10-year period. *Scandinavian Journal of Plastic and Reconstructive Surgery*, Vol.16, pp. 1-132, ISSN 0581-9474

Brånemark, P.I.; Engstrand, P.; Ohrnell, L.O.; Grondahl, K.; Nilsson, P.; Hagberg, K.; Darle, C. & Lekholm, U. (1999). Brånemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. *Clinical Implant Dentistry and Related Research*, Vol.1, No.1, pp. 2-16, ISSN 1523-0899

Brunette, D.M. & Chehroudi, B. (1999). The effects of the surface topography of micromachined titanium substrata on cell behavior in vitro and in vivo. *Journal of Biomechanical Engineering*, Vol.121, No.1, (February 1999), pp. 49–57 ISSN 0148-0731

Burguete, R.L.; Johns, R.B.; King, T. & Patterson, E.A. (1994) Tightening characteristics for screwed joints in osseointegrated dental implants. *The Journal of Prosthetic Dentistry,* Vol.71, No.6, (June 1994), pp. 592-599 ISSN 0022-3913

Buser, D.; Broggini, N.; Wieland, M.; Schenk, R.K.; Denzer, A.J.; Cochran, D.L.; Hoffmann, B.; Lussi, A. & Steinemann, S.G. (2004). Enhanced bone apposition to a chemically modified SLA titanium surface. *Journal of Dental Research*, Vol.83, No.7, (July 2004), pp. 529–533, ISSN 0022-0345

Buser, D.; Nydegger, T.; Hirt, H.P.; Cochran, D.L. & Nolte, L.P. (1998). Removal torque values of titanium implants in the maxilla of miniature pigs. *The International Journal of Oral & Maxillofacial Implants*, Vol.13, No.5, (September-October 1998), pp. 611–619, ISSN 0882-2786

Calvo-Guirado, J.L.; Ortiz-Ruiz, A.J.; López-Marí, L.; Delgado-Ruiz, R.; Maté-Sánchez, J. & Bravo Gonzalez, L.A. (2009). Immediate maxillary restoration of single-tooth implants using platform switching for crestal bone preservation: a 12-month study. *The International Journal of Oral & Maxillofacial Implants*, Vol.24, No.2 (March-April 2009), pp. 275-281, ISSN 0882-2786

Canay, S. & Akça, K. (2009). Biomechanical aspects of bone-level diameter shifting at implant-abutment interface. *Implant Dentistry*, Vol.18, No.3, (June 2009), pp. 239-248, ISSN 1538-2982

Casap, N.; Laviv, A. & Wexler, A. (2011). Computerized navigation for immediate loading of dental implants with a prefabricated metal frame: a feasibility study. *Journal of Oral and Maxillofacial Surgery,* Vol.69, No.2, (February 2011), pp. 512-519, ISSN 0278-2391

Cehreli, M.; Sahin, S. & Akca, K. (2004). Role of mechanical environment and implant design on bone tissue differentiation: current knowledge and future contexts. *Journal of Dentistry,* Vol.31, No.4, (February 2004), pp. 123–132, ISSN 0300-5712

Cehreli, M.C.; Akça, K. & Iplikçioğlu, H. (2004). Force transmission of one- and two-piece morse-taper oral implants: a nonlinear finite element analysis. *Clinical Oral Implants Research*, Vol.15, No.4, (August 2004), pp. 481-489, ISSN 0905-7161

Chen, Y.Y.; Kuan, C.L. & Wang, Y.I. (2008). Implant occlusion: biomechanical considerations for implant-supported prostheses. *Journal of Dental Sciences*, Vol.3, No. 2, pp. 65-74, ISSN 1991-7902

Chiapasco, M.; Abati, S.; Romeo, E. & Vogel, G. (2001). Implant-retained mandibular overdentures with Brånemark System MKII implants: a prospective comparative study between delayed and immediate loading. *The International Journal of Oral & Maxillofacial Implants*, Vol. 16, No.4, (July-August 2001), pp. 537-546, ISSN 0882-2786

Chou, L.; Firth, J.D.; Uitto, V.J. & Brunette, D.M. (1998). Effects of titanium substratum and grooved surface topography on metalloproteinase- 2 expression in human fibroblasts. *Journal of Biomedical Materials Research,* Vol.39, No.3, (March 1998), pp. 437–445, ISSN 1549-3296

Chow, J.; Hui, E.; Liu, J.; Li, D.; Wat, P.; Li, W.; Yau, Y.K. & Law, H. (2001). The Hong Kong Bridge Protocol. Immediate loading of mandibular Brånemark fixtures using a fixed provisional prosthesis: preliminary results. *Clinical Implant Dentistry and Related Research*, Vol. 3, No.3, pp. 166-174, ISSN 1523-0899

Chun, H.J.; Cheong, S.Y.; Han, J.H.; Heo, S.J.; Chung, J.P.; Rhyu, I.C.; Choi, Y.C.; Baik, H.K.; Ku, Y. & Kim M.H. (2002). Evaluation of design parameters of osseointegrated dental implants using finite element analysis. *The Journal of Oral Rehabilitation*, Vol.29, No.6, (June 2002), pp. 565−574, ISSN 0305-182X

Cochran, D.L.; Schenk, R.K.; Lussi, A.; Higginbottom, F.L. & Buser, D. (1998). Bone response to unloaded and loaded titanium implants with a sandblasted and acid-etched surface: a histometric study in the canine mandible. *Journal of Biomedical Materials Research,* Vol. 40, No.1, (April 1998), pp. 1–11, ISSN 1549-3296

Colomina, L.E. (2001). Immediate loading of implant-fixed mandibular prostheses: a prospective 18-month follow-up clinical study-preliminary report. *Implant Dentistry*, Vol.10, No.1, pp. 23-29, ISSN 1056-6163

Conner, K.; Sabatini, R.; Mealey, B.; Takacks, V.; Mill, M. & Cochran, D. (2003). Guided bone regeneration around titanium plasma-sprayed, acid-etched and hydroxyapatite-coated implants in the canine model. *Journal of Periodontology,* Vol.74, No.5, (May 2003), pp. 658–668, ISSN 0022-3492

Da Silva, E.F.; Pellizzer, E.P.; Quinelli Mazaro, J.V. & Garcia Júnior, I.R. (2010). Influence of the connector and implant design on the implant-tooth-connected prostheses. *Clinical Implant Dentistry and Related Research*, Vol.12, No.3, (May 2010), pp. 254-262. ISSN 1523-0899

Davi, L.R.; Golin, A.L.; Bernardes, S.R.; Araujo, C.A. & Neves, F.D. (2008). In vitro integrity of implant external hexagon after application of surgical placement torque simulating implant locking. *Brazilian Oral Research,* Vol.22, No. 2, (April-June 2010), pp. 125-131, ISSN 1807-3107

Dayer, R.; Brennan, T.C.; Rizzoli, R. & Ammann, P. (2010). PTH improves titanium implant fixation more than pamidronate or renutrition in osteopenic rats chronically fed a low protein diet. *Osteoporosis International*, Vol.21, No. 6, (June 2010), pp. 957-967, ISSN 0937-941X

Degidi, M. & Piattelli, A. (2003). Immediate functional and non-functional loading of dental implants: a 2- to 60-month follow-up study of 646 titanium implants. *Journal of Periodontology*, Vol.74, No.2, (February 2003), pp. 225-241, ISSN 0022-3492

Degidi, M. & Piattelli A. (2005). Comparative analysis study of 702 dental implants subjected to immediate functional loading and immediate nonfunctional loading to traditional healing periods with a follow-up of up to 24 months. *The International Journal of Oral & Maxillofacial Implants*, Vol.20, No.1, (January-February 2005), pp. 99-107, ISSN 0882-2786

Dohan Ehrenfest D.M.; Coelho, P.G.; Kang, B.S.; Sul1, Y.T. & Albrektsson, T. (2009). Classification of osseointegrated implant surfaces: materials, chemistry and topography. *Trends in Biotechnology*, Vol.28, No.4, (April 2009), pp. 198-206, ISSN 0167-9430

Duyck, J.; Ronold, H.J.; Van Oosterwyck, H.; Naert, I.; Vander Sloten, J. & Ellingsen, J.E. (2001). The influence of static and dynamic loading on marginal bone reactions around osseointegrated implants: an animal experimental study. *Clinical Oral Implants Research*, Vol.12, No.3, (June 2001), pp. 207-218, ISSN 0905-7161

Elias, C.N.; Oshida, Y.; Lima, J.H. & Muller, C.A. (2008). Relationship between surface properties (roughness, wettability and morphology) of titanium and dental implant removal torque. *Journal of the Mechanical Behavior of Biomedical Materials*, Vol.1, No.3, (July 2008), pp. 234-242, ISSN 1751-6161

Engquist, B.A.; Strand, P.; Dahlgren, S.; Engquist, E.; Feldmann, H. & Grondahl, K. (2002). Marginal bone reaction to oral implants: a prospective comparative study of Astra Tech and Brånemark system implants. *Clinical Oral Implants Research*, Vol.13, No.1, (February 2002), pp. 30–37, ISSN 0905-7161

Ericsson, I.; Randow, K.; Glantz, P.O.; Lindhe, J. & Nilner, K. (1994). Clinical and radiographical features of submerged and nonsubmerged titanium implants. *Clinical Oral Implants Research*, Vol.5, No.3, (September 1994), pp. 185-189, ISSN 0905-7161

Esposito, M.; Hirsch, J.M.; Lekholm, U. & Thomsen, P. (1998). Biological factors contributing to failures of osseointegrated oral implants. (I) Success criteria and epidemiology. *European Journal of Oral Sciences*, Vol.106, No.1 (February 1998), pp. 527–551, ISSN 0909-8836

Esposito, M.; Grusovin, M.G.; Achille, H.; Coulthard, P. & Worthington, H.V. (2009). Interventions for replacing missing teeth: different times for loading dental implants. *Cochrane Database Systematic Review*, Vol.21, CD 003878, DOI 10.1002/14651858

Fitzgerald, M.; O´Sullivan, M.; O´Connell.B. & Houston, F. (2010). Accuracy of bone mapping and guided flapless implant placement in human cadavers using a model-based planning procedure.*The International Journal of Oral & Maxillofacial Implants,* Vol.25, No.5, (September-October 2010), pp. 999-1006, ISSN 0882-2786

Fortin, T.; Bosson, J.L.; Coudert, J.L. & Isidori, M. (2003). Reliability of preperative planning of an image-guided system for oral implant placement based on 3-dimensional images: An in vivo study. *The International Journal of Oral Maxillofacial Implants,* Vol. 18, No.6, (November-December 2003), pp. 886-893, ISSN 0882-2786

Gatti, C.; Haefliger, W. & Chiapasco, M. (2000). Implant-retained mandibular overdentures with immediate loading: A prospective study of ITI implants. *The International Journal of Oral Maxillofacial Implants*, Vol.15, No.3, (May-June 2000), pp. 383-388, ISSN 0882-2786

Geng, J.; Tan, K.B.C. & Liu, G. (2001). Application of finite element analysis in implant dentistry: a review of the literature. *The Journal of Prosthetic Dentistry,* Vol.85, No.6 (June 2001), pp. 585–598, ISSN 0022-3913

Geng, J.P.; Ma, Q.S.; Xu, W.; Tan, K.B. & Liu, G.R. (2004). Finite element analysis of four thread form configurations in a stepped screw implant. *The Journal of Oral Rehabilitation*, Vol.31, No.3 (March 2004), pp. 233–239, ISSN 0305-182X

Goodacre, C.J.; Bernal, G.; Runcharassaeng, K. & Kan, J.Y.K. (2003). Clinical complications with implants and implant prostheses. *The Journal of Prosthetic Dentistry*, Vol. 90, No.2, (August 2003), pp. 121-132, ISSN 0022-3913.

Götz, H.E.; Müller, M.; Emmel, A.; Holzwarth, U.; Erben, R.G. & Stangl, R. (2004). Effect of surface finish on the osseointegration of laser-treated titanium alloy implants. *Biomaterials*, Vol.25, No.18, (August 2004), pp. 4057-4064, ISSN 0142-9612

Gross, M.D. (2008). Occlusion in implant dentistry. A review of the literature of prosthetic determinants and current concepts. *Australian Dental Journal,* Vol.53, No.1, (June 2008), pp. S60-S68, ISSN 1834-7819

Hebel, K.S. & Gajjar, R.C. (1997). Cement-retained versus screw-retained implant restorations: Achieving optimal occlusion and esthetics in implant dentistry. *The Journal of Prosthetic Dentistry,* Vol.77, No., (January 1997), pp. 28-35, ISSN 0022-3913

Heydenrijk, K.; Raghoebar, G.M.; Meijer, H.J.A.; van der Reijden, W.A.; van Winkelhoff, A.J. & Stegenga, B. (2002). Two-stage IMZ implants and ITI implants inserted in a single stage procedure. A prospective comparative study. *Clinical Oral Implants Research,* Vol.13, No.4, (August 2002), pp. 371–380, ISSN 1523-0899

Holmgren, E.P.; Seckinger, R.J.; Kilgren, L.M. & Mante, F. (1998). Evaluating parameters of osseointegrated dental implants using finite element analysis—a two-dimensional comparative study examining the effects of implant diameter, implant shape, and load direction. *Journal of Oral Implantology*, Vol. 24, No.2, pp. 80–88, ISSN 0160-6972

Hunt, P.R.; Gartner, J.L. & Norkin, F.J. (2005). Choice of a dental implant system. *Compendium of Continuing Education in Dentistry*, Vol.26, No.4, (April 2005), pp. 239-240, 242,245-248 passim, quiz 251, 271, ISSN 1548-8578

Jones, A.A. & Cochran, D.L. (2006). Consequences of implant design. *Dental Clinics of North America*, Vol.50, No.3, (July 2006), pp. 339-360, ISSN 0011-8532.

Jung, R.E.; Schneider, D.; Ganeles, J.; Wismeijer, D.; Zwahlen, M.; Hämmerle, C.H.F. &Tahmaseb, A. (2009). Computer technology applications in surgical implant dentistry: A systematic review. *The International Journal of Oral & Maxillofacial Implants,* Vol.24, (Suppl 2009), pp. 92-109, ISSN 0882-2786

Kasemo, B. & Lausma, J. (1998). Biomaterial and implant surfaces: a surface science approach. *The International Journal of Oral & Maxillofacial Implants*, Vol.3, No.4, (Winter 1988), pp. 247-259, ISSN 0882-2786

Kenney, R. & Richards, M.W. (1998). Photoelastic stress patterns produced by implant-retained overdentures. *The Journal of Prosthetic Dentistry*, Vol.80, No.5, (November 1998), pp. 559-564, ISSN 0022-3913

Kong, L.; Sun, Y.; Hu, K.; Liu, Y.; Li, D.; Qiu, Z. & Liu, B. (2008). Selections of the cylinder implant neck taper and implant end fillet for optimal biomechanical properties: a three-dimensional finite element analysis. *Journal of Biomechanical*, Vol.41, No. 5, (February 2008), pp. 1124-1130, ISSN 0021-9290

Kozlovsky, A.; Tal, H.; Laufer, B.Z.; Leshem, R.; Rohrer, M.D.; Weinreb, M. & Artzi, Z. (2007). Impact of implant overloading on the peri-implant bone in inflamed and non-inflamed peri-implant mucosa. *Clinical Oral Implants Research*, Vol. 18, No.5, (October 2007), pp. 601- 610, ISSN 0905-7161

Krennmair, G.; Schmidinger, S. & Waldenberger, O. (2002). Single-tooth replacement with the frialit-2 system: A retrospective clinical analysis of 146 implants. *The International Journal of Oral & Maxillofacial Implants*, Vol.17, No.1, (January-February 2002), pp. 78-85, ISSN 0882-2786

Ku, Y.; Chung, C.P. & Jang, J.H. (2005). The effect of the surface modification of titanium using a recombinant fragment of fibronectin and vitronectin on cell behaviour. *Biomaterials*, Vol.26, No.25, (September 2005), pp. 5153-5157, ISSN 0142-9612

Le Guéhennec, L.; Soueidan, A.; Layrolle, P. & Amouriq, Y. (2007). Surface treatments of titanium dental implants for rapid osseointegration. *Dental Materials*, Vol.23, No.7, (July 2007), pp. 844-854, ISSN 0109-5641

Lee, B.H.; Do Kim, Y.; Shin, J.H. & Hwan Lee, K. (2002). Surface modification by alkali and heat treatments in titanium alloys. *Journal of Biomedical Materials Research*, Vol.61, No.5, (September 2002), pp. 466-473, ISSN 1549-3296

Lee, B.H.; Lee, C.; Kim, D.G.; Kuiwon, C.; Lee, K.H. & Young, D.K. (2008). Effect of surface structure on biomechanical properties and osseointegration. *Materials Science and Engineering. C*, Vol.28, No.8, (December 2008), pp. 1448-1461, ISSN 0928-4931

Lee, C.C.; Lina, S.C.; Kanga, M.J.; Wua, S.W. & Fu, P.Y. (2010). Effects of implant threads on the contact area and stress distribution of marginal bone. *Journal of Dental Sciences*, Vol.5, No.3, (September 2010), pp. 156-165, ISSN 1343-4934

Levine, R.A.; Clem, D.S.; Wilson, T.G.; Higginbottom, F. & Solnit, G. (1999). Multicenter retrospective analysis of the ITI implant system used for single-tooth replacements: Results of loading for 2 or more years. *The International Journal of Oral and Maxillofacial Implants*, Vol.14, No.4, (July-August 1999), pp. 516-520, ISSN 0882-2786

Maeda, Y.; Satoh, T. & Sogo, M. (2006). In vitro differences of stress concentrations for internal and external hex implant-abutment connections: A short communication. *The Journal of Oral Rehabilitation*, Vol.33, No.1, (January 2006), pp. 75–78, ISSN 0305-182X

Mailath, G.; Stoiber, B.; Watzek, G. & Matejka, M. (1989). Bone resorption at the entry of osseointegrated implant - a biomechanical phenomenon. Finite element study. *Z Stomatol*, Vol.86, No.4, (June 1989), pp. 207–216, ISSN 0175-7784

Malo, P.; Araujo-Nobre, M. & Lopes, A. (2007). The use of computer-guided flapless implant surgery and four implants placed in immediate function to support a fixed denture: Preliminary results after a mean follow-up period of thirteen months. *The Journal of Prosthetic Dentistry*, Vol.97, No.6, (Suppl 2007), pp. 26-34, ISSN 0022-3913

Mandelaris, G.A.; Rosenfeld, A.L.; King, S.D. & Nevins, M.L. (2010). Computer-guided implant dentistry for precise implant placement: combining specialized stereolithographically generated drilling guides and surgical implant instrumentation. *The International Journal of Periodontics and Restorative Dentistry*, Vol.301, No.3, (June 2010), pp.275-281, ISSN 0198-7569

Mangano, C.; Mangano, F.; Piattelli, A.; Iezzi, G.; Mangano, A. & La Colla L. (2009). Prospective clinical evaluation of 1920 Morse taper connection implants: results after 4 years of functional loading. *Clinical Oral Implants Research*, Vol.20, No.3, (March 2009), pp. 254-261, ISSN 1523-0899

Mavrogenis, A.F.; Dimitriou, R.; Parvizi, J. & Babis, G.C. (2009). Biology of implant osseointegration. *Journal of Musculoskeletal and Neuronal Interactions*, Vol.9, No.2, (April-June 2009), pp. 61-71, ISSN 1108-7161

Meloni, S.M.; De Riu, G.; Pisano, M.; Cattina, G. & Tullio, A. (2010). Implant treatment software planning and guided flapless surgery with immediate provisional prosthesis delivery in the fully edentulous maxilla. A retrospective analysis of 15 consecutively treated patients. *European Journal of Oral Implantology*, Vol.3, No.3, (Autumn 2010), pp. 245-251, ISSN 1756-2406

Merz, B.R.; Hunenbart, S. & Belser, U.C. (2000). Mechanics of the implant abutment connection: an 8-degree taper compared to a butt joint connection. *International*

Journal of Oral and Maxillofacial Implants, Vol.15, No.4, (July-August 2000), pp. 519-526, ISSN 0882-2786

Misch, C.E. & Bidez, M.W. (1995). Implant-protected occlusion. *Practical Periodontics and Aesthetic Dentistry*, Vol.7, No.5, (June-July 1995), pp. 25-29, ISSN 1042-2722

Misch, C.E.; Qu, Z. & Bidez, M.W. (1999). Mechanical properties of trabecular bone in the human mandible: Implications for dental implant treatment planning and surgical placement. *Journal of Oral Maxillofacial Surgery*, Vol.57, No.6, (June 1999), pp. 700-706, ISSN 0278-2391

Misch, C.E. & Wang, H.L. (2003). Immediate occlusal loading for fixed prostheses in implant dentistry. *Dentistry Today*, Vol. 22, No.8, (August 2003), pp. 50-56, ISSN 8750-2186

Misch, C.E.; Wang, H.L.; Misch, C.M.; Sharawy, M.; Lemons, J.; Judy, K.W. (2004a). Rationale for the application of immediate load in implant dentistry: Part I. *Implant Dentistry*, Vol.13, No.3, (September 2004), pp. 207-217, ISSN 1056-6163

Misch, C.E.; Wang, H.L.; Misch, C.M.; Sharawy, M.; Lemons, J. & Judy, K.W. (2004b). Rationale for the application of immediate load in implant dentistry: part II. *Implant Dentistry*, Vol.13, No.4, (December 2004), pp. 310-321, ISSN 1056-6163

Misch, C.E.; Steignga, J.; Barboza, E.; Misch-Dietsh, F.; Cianciola, L.J. & Kazor, C. (2006). Short dental implants in posterior partial edentulism: a multicenter retrospective 6-year case series study. *Journal of Periodontology*, Vol.77, No.8, (August 2006), pp. 1340-1347, ISSN 0022-3492

Misch, C.E. (2008). Contemporary Implant Dentistry (3rd ed), Mosby, ISBN 0323043739, St Louis, USA

Morris, H.F.; Winkler, S.; Ochi, S. & Kanaan, A. (2001). A new implant designed to maximize contact with trabecular bone: survival to 18 months. *Journal of Oral Implantology*, Vol.27, No.4, pp. 164-173, ISSN 0160-6972

Morton, D.; Jaffin, R. & Weber, H.P. (2004). Immediate restoration and loading of dental implants: Clinical considerations and protocols. *The International Journal of Oral Maxillofacial Implants,* Vol.19, (Suppl 2004), pp. 103-108, ISSN 0882-2786

Nkenke, E.; Lehner, B.; Fenner, M.; Roman, F.S.; Thams, U.; Neukam, F.W. & Radespiel-Tröger M. (2005). Immediate versus delayed loading of dental implants in the maxillae of minipigs: follow-up of implant stability and implant failures. *The International Journal of Oral & Maxillofacial Implants*, Vol.20, No.1, (January-February 2005), pp. 39-47, ISSN 0882-2786

Nokar, S. & Baghai Naini, R. (2010). The effect of superstructure design on stress distribution in peri-implant bone during mandibular flexure. *The International Journal of Oral & Maxillofacial Implants*, Vol.25, No.1, (January-February 2010), pp. 31-37, ISSN 0882-2786

Patel, N. (2010). Integrating three-dimensional digital technologies for comprehensive implant dentistry. *The Journal of the American Dental Association*, Vol.141, (Suppl 2), pp. 20S-24S, ISSN 0002-8177

Pellizzer, E.; Tonella, B.; Ferraco, R.; Falcon-Antenucci, R.M.; de Carvalho, P.S. & Goiato, M. (2010). Photoelastic analysis of cemented or screwed implant-supported prostheses with different prosthetic connections. *The Journal of Oral Implantology,*. Vol.16 (August 2010), pp. 1-19, ISSN 0160-6972

Pessoa, R.S.; Muraru, L.; Junior, E.M.; Vaz, L.G.; Sloten, J.V.; Duyck, J. & Jaecques, S.V. (2010). Influence of implant connection type on the biomechanical environment of immediately placed implants - ct-based nonlinear, three-dimensional finite element analysis. *Clinical Implant Dentistry and Related Research,* Vol.12, No.3, (September 2010), pp. 219-234, ISSN 1708-8208

Piattelli, A.; Ruggeri, A.; Franchi, M.; Romasco, N. & Trisi, P.A. (1993). An histologic and histomorphometric study of bone reactions to unloaded and loaded non-submerged single implants in monkeys: a pilot study. *Journal of Oral Implantology,* Vol.19, No.4, pp. 314-320, ISSN 0160-6972

Pieri, F., Aldini, N.N., Marchetti, C. & Corinaldesi, G. (2011). Influence of implant-abutment interface design on bone and soft tissue levels around immediately placed and restored single-tooth implants: A randomized controlled clinical trial. *The International Journal of Oral & Maxillofacial Implants*, Vol.26, No.1, (January-February 2011), pp. 169-178, ISSN 0882-2786.

Pilliar, R.M.; Lee, J.M. & Maniatopoulos, C. (1986) Observation of the effect of movement on the bone ingrowth into porous surfaced implants. *Clinical Orthopaedics and Related Research,* Vol.208 (July 1986), pp. 108–113, ISSN 0009-921X

Prosper, L.; Redaelli, S.; Pasi, M.; Zarone, F.; Radaelli, G. & Gherlone, E.F. (2009). A randomized prospective multicenter trial evaluating the platform- switching technique for the prevention of postrestorative crestal bone loss. *The International Journal of Oral & Maxillofacial Implants*, Vol.24, No.2, 9 (March-April 2009), pp. 299-308, ISSN 0882-2786

Puig, C.P. (2010). A retrospective study of edentulous patients rehabilitated according to the “all-on-four” or the “all-on-six” immediate function concept using flapless computer-guided implant surgery. *European Journal of Oral Implantology*, Vol.3, No.2, (Summer 2010), pp. 155-163, ISSN 1756-2406

Puleo, D.A. (2006). Thomas MV. Implant surfaces. *Dental Clinics of North America*, Vol.50, No.3, (July 2006), pp. 323-338, ISSN 0011-8532

Qu, J.; Chehroudi, B.; Brunette, D.M. (1996). The use of micromachined surfaces to investigate the cell behavioral factors essential to osseointegration. *Oral Disease*, Vol.2, No.1, (March 1996), pp. 102–115, ISSN 1354-523X

Rieger, M.R.; Adams, W.K. & Kinzel, G.L. (1990). A finite element survey of eleven endosseous implants. *The Journal of Prosthetic Dentistry*, Vol.63, No.4, (April 1990), pp. 457-465. ISSN 0022-3913

Romeo, E.; Lops, D.; Margutti, E.; Ghisolfi, M.; Chiapasco, M. & Vogel, G. (2004). Long-term survival and success of oral implants in the treatment of full and partial arches: a 7-year prospective study with the ITI dental implant system. *The International Journal of Oral & Maxillofacial Implants*, Vol.19, No.2, (March-April 2004), pp. 247-259, ISSN 0882-2786

Sabet, M.E.; El-Korashy, D.I. & El-Mahrouky, N.A. (2009). Effect of platform switching on strain developed around implants supporting mandibular overdenture. *Implant Dentistry*, Vol.18, No.4, (August 2009), pp. 362-370, ISSN 1538-2982

Schenk, R. K. & Buser, D. (1998). Osseointegration: a reality. *Periodontology 2000,* Vol.17, No.1, (June 1998), pp. 22-35, ISSN 0906-6713

Schneider, D.; Marquardt, P.; Zwahlen, M. & Jung, R.E. (2009). A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. *Clinical Oral Implants Research,* Vol.20, (Suppl 4 2009), pp. 73-86, ISSN 0905-7161

Schnitman, P.A.; Wöhrle, P.S.; Rubenstein, J.E.; DaSilva, J.D. & Wang, N.H. (1997). Ten-years results for Brånemark implants immediately loaded with fixed prostheses at implant placement. *The International Journal of Oral & Maxillofacial Implants*, Vol.12, No.4, (July-August 1997), pp. 495-503, ISSN 0882-2786

Schulte, J.K. (1994) External hex manufacturing tolerances of six implant systems: A pilot study. *Implant Dentistry*, Vol.3, No.1, (Spring 1994), pp. 51-53, ISSN 1056-6163

Serrano-Sánchez, P.; Manzanera-Pastor, E.; Lorrio-Castro, C.; Bretones-López, P.; Garcia-Serrano, A. & Calvo-Guirado, J.L. (2011). Influence of platform switching in dental implants. A literature review. *Medicina Oral Patologia Oral y cirurgia Bucal* , Jan 3. [Epub ahead of print]. ISSN 1698-6946

Siegele, D. & Soltesz, U. (1989). Numerical investigations of the influence of implant shape on stress distribution in the jaw bone. *The International Journal of Oral & Maxillofacial Implants*, Vol.4, No.4 (Winter 1989), pp. 333-340, ISSN 0882-2786

Stanford C.M. (2008). Surface modifications of dental implants. *Australian Dental Journal*, Vol.53, (Suppl S1 June 2008), pp. S26-S33, ISSN 0045-0421

Steigenga J.T.; al-Shammari, K.F.; Nociti, F.H.; Misch, C.E. & Wang, H.L. (2003). Dental implant design and its relationship to long-term implant success. *Implant Dentistry*, Vol.12, No.4, pp. 306-317, ISSN 1056-6163

Strong, J.T.; Misch, C.E.; Bidez, M.W. & Nalluri, P. (1998). Functional surface area: thread-form parameter optimization for implant body design. *Compendium of Continuing Education in Dentistry*, Vol.19, No.3, (supplement 2 1998), pp. 4-9, ISSN 1548-8578

Sul, Y.T.; Johansson, C.B.; Roser, K. & Albrektsson, T. (2002). Qualitative and quantitative observations of bone tissue reactions to anodized implants. *Biomaterials*, Vol.23, No.8, (April 2002), pp. 1809-1817, ISSN 0142-9612

Suzuki, K.; Aoki, K. & Ohya, K. (1997). Effects of surface roughness of titanium implants on bone remodeling activity of femur in rabbits. *Bone*, Vol.21, No.6, (December 1997), pp. 507-514, ISSN 8756-3282

Sykaras, N.; Iacopino, A.M.; Marker, V.A., Triplett, R.G. & Woody, R.D. (2000). Implant materials, designs, and surface topographies: their effect on osseointegration. A literature review. *The International Journal of Oral & Maxillofacial Implants*, Vol.15, No.5, (September-October 2000), pp. 675-690. ISSN 0882-2786

Szmukler-Moncler, S.; Salama, H.; Reingewirtz, Y. & Dubruille, J.H. (1998). Timing of loading and effect of micromotion on bone-dental implant interface: review of experimental literature. *Journal of Biomedical Materials Research,* Vol.43, No.2, (Summer 1998), pp. 192–203, ISSN 1549-3296

Tesmer, M.; Wallet, S.; Koutouzis, T. & Lundgren, T. (2009). Bacterial colonization of the dental implant fixture-abutment interface: an in vitro study. *Journal of Periodontology*, Vol.80, No.12, (December 2009), pp. 1991-1997, ISSN 1566-0702

Testori, T.; Wiseman, L.; Woolfe, S. & Porter, S. (2001). A prospective multicenter clinical study of the Osseotite implant: four-year interim report. *The International Journal of Oral & Maxillofacial Implants,* Vol.16, No.2, (March-April 2001), pp. 193–200. ISSN 0882-2786

Thakur, A.J. (1997). *The Elements of Fracture Fixation* (1st ed), Churchill Livingstone, ISBN 0443055475, New York, USA

Toyoshima, T.; Wagner, W.; Klein, M.O.; Stender, E.; Wieland, M. & Al-Nawas, B. (2011). Primary stability of a hybrid self-tapping implant compared to a cylindrical nonself-tapping implant with respect to drilling protocols in an ex vivo model. *Clinical Implant Dentistry and Related Research*, Vol.13, No.1, (March 2011), pp. 71-78, ISSN 0905-7161

Triplett, R.G.; Frohberg, U.; Sykaras, N. & Woody, R.D. (2003). Implant materials, design, and surface topographies: their influence on osseointegration of dental implants. *Journal of Long-Term Effects of Medical Implants*, Vol.13, No.6, pp. 485-501, ISSN 1050-6934

Turkyilmaz, I.; Suarez, J.C.; Company, A.M. & McGlumphy EA. (2009). Early load mandibular hybrid prosthesis using the OSU acrylic frame requiring no final impression. *Australian Dental Journal*, Vol.54, No.3, (September 2009), pp. 255-261, ISSN 1834-7819.

Upp, F.; Scheideler, L.; Olshanska, N.; de Wld, M.; Wieland, M. & GeisGesttorfer, J. (2006). Enhancing surface free energy and hydrophilicity through modification of microstructured titanium implant surface. *Journal of Biomedical Materials Research,* Vol.76, No.2, (February 2006), pp. 323-324, ISSN 1552-4965

van Steenberghe, D.; Naert, I.; Jacobs, R. & Quirynen, M. (1999). Influence of inflammatory reactions vs. occlusal loading on peri-implant marginal bone level. *Advances in Dental Research,* Vol.13, (June 1999), pp. 130-135, ISSN 0895-9374

Vasak, C.; Watzak, G.; Gahleitner, A.; Strbac, G.; Schemper, M. & Zechner, W. (2011). Computed tomography-based evaluation of template (NobelGuide)-guided implant positions: a prospective radiological study. *Clinical Oral Implants Research,* doi: 10.1111/j.1600-0501.2010.02070, ISSN 0905-7161

Vidyasagar, L. & Apse, P. (2004). Dental implant design and biological effects on bone-implant interface. *Baltic Dental and Maxillofacial Journal*, Vol.6, No.2, (June 2004), pp. 51-54, ISSN 1392-8589

Weng, D.; Jacobson, Z.; Tarnow, D.; Hürzeler, M.B.; Faehn, O.; Sanavi, F.; Barkvoll, P. & Stach, R.M. (2003). A prospective multicenter clinical trial of 3i machined-surface implants: Results after 6 years of follow-up. *The International Journal of Oral & Maxillofacial Implants*, Vol.18, No.3, (May-June 2003), pp. 417-423, ISSN 0882-2786

Wennerberg, A.; Albrektsson, T. & Andersson, B. (1995). An animal study of cp titanium screws with different surface topographies. *Journal of Materials Science: Materials in Medicine,* Vol.6, No.5, pp. 302–309, ISSN 0957-4530

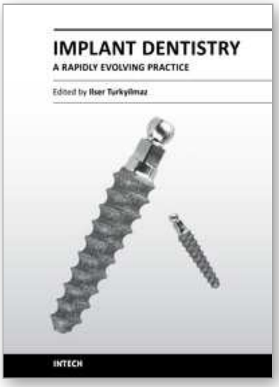
Wiskott, H.W. & Belser, U.C. (1999). Lack of integration of smooth titaniumsurfaces: A working hypothesis based on strains generated in the surrounding bone [review]. *Clinical Oral Implants Research*, Vol.1, No.6, (December 1999), pp. 429–444. ISSN 0905-7161

Yamada, K.; Hoshina, H.; Arashiyama, T.; Arasawa, M.; Arai, Y.; Uoshima, K.; Tanaka, M. & Nomura, S. (2011). Immediate implant loading following computer-guided surgery. *Journal of Prosthodontic Research,* doi:10.1016/j.por.2010.11.002, ISSN 1883-1958

Zarone, F.; Apicella, A.; Nicolais, L.; Aversa, R. & Sorrentino, R. (2003). Mandibular flexure and stress build-up in mandibular full-arch fixed prostheses supported by osseointegrated implants. *Clinical Oral Implants Research*, Vol.14, No.1, (February 2003), pp. 103-114, ISSN 0905-7161

Zhao, G.; Schwartz, Z.; Wieland, M.; Rupp, F.; Geis-Gerstorfer, J.; Cochran, D.L. & Boyan, B.D. (2005). High surface energy enhances cell response to titanium substrate microstructure. *Journal of Biomedical Materials Research Part A,* Vo.74, No.1, (July 2005), pp. 49-58. ISSN 1552-4965

Zubery, Y.; Bichacho, N.; Moses, O. & Tal, H. (1999). Immediate loading of modular transitional implants: a histologic and histomorphometric study in dogs. *International Journal of Periodontics & Restorative Dentistry*, Vol.19, No.4, (August 1999), pp. 343-353, ISSN 0198-7569



Implant Dentistry - A Rapidly Evolving Practice
Edited by Prof. Ilser Turkyilmaz

ISBN 978-953-307-658-4
Hard cover, 544 pages
Publisher InTech

Published in print edition August, 2011

Implant dentistry has come a long way since Dr. Branemark introduced the osseointegration concept with endosseous implants. The use of dental implants has increased exponentially in the last three decades. As implant treatment became more predictable, the benefits of therapy became evident. The demand for dental implants has fueled a rapid expansion of the market. Presently, general dentists and a variety of specialists offer implants as a solution to partial and complete edentulism. Implant dentistry continues to evolve and expand with the development of new surgical and prosthodontic techniques. The aim of Implant Dentistry - A Rapidly Evolving Practice, is to provide a comtemporary clinic resource for dentists who want to replace missing teeth with dental implants. It is a text that relates one chapter to every other chapter and integrates common threads among science, clinical experience and future concepts. This book consists of 23 chapters divided into five sections. We believe that, Implant Dentistry: A Rapidly Evolving Practice, will be a valuable source for dental students, post-graduate residents, general dentists and specialists who want to know more about dental implants.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

José Mauricio dos Santos Nunes Reis, Lîgia Antunes Pereira Pinelli, Nicolau Conte Neto, Marcelo Silva Monnazzi and José Cláudio Martins Segalla (2011). An Overview Regarding Contemporary Biomechanical Aspects on Immediate Loading Dental Implants, Implant Dentistry - A Rapidly Evolving Practice, Prof. Ilser Turkyilmaz (Ed.), ISBN: 978-953-307-658-4, InTech, Available from: http://www.intechopen.com/books/implant-dentistry-a-rapidly-evolving-practice/an-overview-regarding-contemporary-biomechanical-aspects-on-immediate-loading-dental-implants

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821