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DISSERTATION

Radiographic Evaluation of Crestal Bone Level Changes Around Implants and Abutment with Non-corresponding Diameters: A Prospective Pilot Study

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Contents

1. Zusammenfassung

Radiologische Bewertung der krestalen Knochenhöhe Veränderungen rund um Implantate und Abutments mit nicht entsprechenden Durchmesser: Eine prospektive Pilotstudie

Einführung: Die postrestorative Reduzierung der periimplantären Knochenhöhe von 1.5 – 2 mm nach 1 Jahr ist seit langem als eine normale Folge der Implantattherapie mit 2-teiligen Implantaten anerkannt. Der Begriff Platform-Switching bezieht sich auf die Verwendung eines kleineren Abutmentdurchmessers im Vergleich zum Durchmesser der Implantatschulter. Studien zeigen widersprüchliche Ergebnisse bezüglich des Nutzens von Platform-Switching. **Material und Methoden:** Die radiologische Auswertung des periimplantären Knochenverlustes innerhalb eines Jahres um zwei zweiteilige Implantatsysteme (Bone-Level-Implantat und wi.tal Implantat) mit platform-switching wurde an Hand von Orthopantomogrammen durchgeführt. **Ergebnisse:** In der wi.tal Implantat Gruppe betrug der mittlere Knochenverlust 1,16 mm (mesial) und 1,23 mm (distalen) über die Zeit; in der Bone-Level-Implantat-Gruppe, war der mittlere krestale Knochenverlust 0,73 mm (mesial) und 0,78 mm (distal). Der mesiale (p=0,012) und distale (p=0,014) krestale Knochenverlust war signifikant unterschiedlich zwischen wi.tal und Bone-Level-Implantaten. **Diskussion:** In dieser Studie war ein erhöhter krestaler Knochenverlust zu verzeichnen bei Implantaten die unter dem Knochenniveau platziert wurden. Es scheint wichtig, dass ein bestimmter Abstand zwischen dem Implantat-Abutment-Interface und dem krestalen Knochenniveau einzuhalten ist. Obwohl zwischen der wi.tal Implantatgruppe und Bone-Level-Implantat-Gruppe der horizontale Abstand vom Implantat-Abutment-Interface der Gleiche (0,4 mm) ist, hat die suprakrestale Platzierung der wi.tal Implantatschulter einen periimplantären Knochenabbau nicht verhindern können. Die meisten Studien beginnen mit der Messung der krestalen Knochenhöhe erst nach prothetischer Versorgung und nicht ab dem Tag der Implantatinsertion. **Schlussfolgerungen:** Die Studie zeigt das platform-switching nicht immer einen periimplantären Knochenabbau verhindert wie im Falle des wital Implantates. Weiterführende Studien sollten weitere Einflussfaktoren bestimmen.

2. Abstract

Radiographic evaluation of crestal bone level changes around implants and abutment with non-corresponding diameters: A prospective pilot study

Introduction: For the two-piece implant, the crestal bone levels have been described to be typically located approximately 1.5 to 2 mm below the implant-abutment junction (IAJ) at 1 year following implant restoration at the level the first thread of the two-piece implant. The term platform switching refers to the use of a smaller diameter abutment on a larger diameter implant collar. Some studies showed platform switching may help decrease the crestal bone loss but the results are still controversial. **Materials and methods:** This clinical radiologic evaluation retrospective study evaluated the peri-implant bone loss around two platform-switched implants (Bone-level implant and Wi.tal implant) with different implant-abutment connection designs with radiological examination over time. **Result:** In Wi.tal implant group, the mean crest bone loss were 1.16 mm (mesial) and 1.23 mm (distal) over time; in Bone-level implant group, the mean crestal bone loss was 0.73 mm (mesial) and 0.78 mm (distal) accordingly; the mesial ($p=0.012$) and distal ($p=0.014$) crestal bone loss was significantly different between Wi.tal and Bone-level implants. An increased vertical distance of the implant-abutment interface relative to the bone crest may reduce the amount of bone loss. **Discussion:** In this study, crestal bone loss increased when the implants were placed below the bone crest. It does seem important to keep the distance between the implant-abutment interface and the crestal bone surface. But between the Wi.tal implant group and Bone-level implant group, the horizontal distance from the implant-abutment interface to the edge of platform is the same (0.4 mm), supracrestal placement of Wi.tal implant shoulder did not prevent bone loss. The importance of the present study is the measurement of actual crestal bone loss around implant from the day of implant placement till the end of follow-up time. Most of platform-switching studies consider the distance between the shoulder of implant platform and bone-implant contact as crestal bone loss after follow up time, but without measuring the initial crestal bone height (bone above the platform shoulder or below the platform shoulder) on the day of implant placement. We assess the coronal bone loss at the implant platform during healing period, after abutment attachment and implant loaded. **Conclusion**: Platform-switching does not always reduce the amount of bone loss. It still needs further studies to clarify the factors influencing crestal bone changes at the implant shoulder.

3. Introduction

In our life, good teeth mean health and confidence, which is essential for a good quality of life. Missing teeth might bring problems for a healthy life [1]. For decades the solutions for the replacement of missing teeth were bridges and removable dentures, but they could not solve all esthetic and functional problems [2]. In 1977 Brånemark described the direct integration of titanium in bone and defined it osseointegration: the apparent direct attachment or connection of osseous tissue to an inserted alloplastic material without intervening connective tissue [3]. Since then various endosseous implant systems have been developed. Dental implants can replace missing teeth and provide adequate long-term success rates [4, 5]. In the early years, research mainly focused on the advent of hard tissue integration, on the design of two-piece implants and their surface roughness [6-12]. The design varies between blade or screw-type implants, from smooth surfaces to rough surfaces [11,13-16]. The success rates for rough-surfaced endosseous implants have been shown to be greater than 90% [17-19]. Hence, a great amount of the recent research on implants concentrates on improving the predictability of implant restorations and optimizing esthetics [20-23]. The challenge for the dentist is to fulfill the increasing esthetic demands for the replacement of missing teeth in the area of the anterior teeth area, the so called “esthetic zone”, with the restoration of natural-appearing anatomy surrounding the implant [24-27]. Modern dental implants have a two-piece design, the implant body, or “root” portion of the implant is the part which is placed into the bone and which ultimately bonds to the bone(Figure1). It resembles a screw on the outside and has an internal threaded cylinder which can accept a number of different attachments, the “abutment” which is then screwed into the implant body to support the prosthetic restoration. The “prosthetic restoration” can be a single crown, several crowns, partial denture, or full denture.

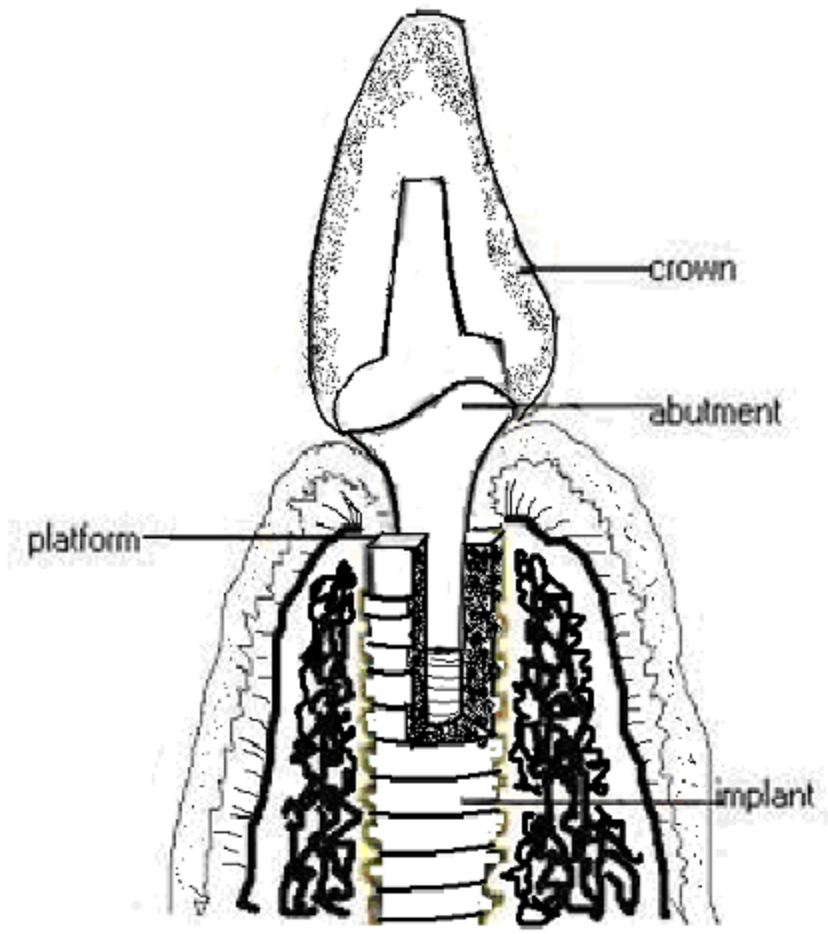


Figure 1: Two-piece implant and abutment structure

For the two-piece implant, crestal bone loss occuring around the implant shoulder has been described [28-33]. Crestal bone loss will induce recession of the gingival margin influencing esthetics [20, 21, 34-37]. As a consequence, increasing attention has been given to study the peri-implant crestal bone loss. Only with careful consideration of the biologic principles of the peri-implant hard and soft tissue, as well as the appropriate selection of implant type and position, a stable esthetic implant supported restoration can be achieved.

3.1. Factors which may influence the preservation of the crestal bone around the implant

Postrestorative reduction in peri-implant bone height has long been acknowledged to be a normal consequence of implant therapy involving 2-piece implants [28, 31, 38-40]. The crestal bone levels have been described to be typically located approximately 1.5 to 2 mm below the implant-abutment junction (IAJ) at 1 year following implant restoration at the level of the first thread of two-piece implants [28]. This has been described to be depending on the location of the IAJ in relation to the bone crest [41, 42]. Several factors are suggested to contribute to the bone remodeling around the implant neck.

3.1.1. Biologic width

In 1921, Gottlieb initially described the “epithelial attachment” around a natural tooth by covering distinct areas of the enamel surface or the cementum [43]. These findings were confirmed by Orban & Mueller [44], and the “gingival crevice” or sulcus was since defined. The connective tissue consists of three-dimensionally oriented fibers firmly connecting tooth structures to the surrounding gingiva [45] and was called “dentogingival junction” [46]. In 1961, Gargiulo defined the vertical dimension of the dentogingival junction as “Biologic Width” which comprises the sulcus depth (SD), junctional epithelium (JE), and connective tissue attachment (CTA). “Biologic Width” is a physiologically formed and stable dimension, and this unit forms at a level dependent on the location of the crest of the alveolar bone. It is the distance established by "the junctional epithelium and connective tissue attachment to the root surface" of a tooth, the distance is said to be 2 mm on average, of which 1 mm is epithelial attachment and 1 mm is connective tissue attachment (Figure 2) [47].

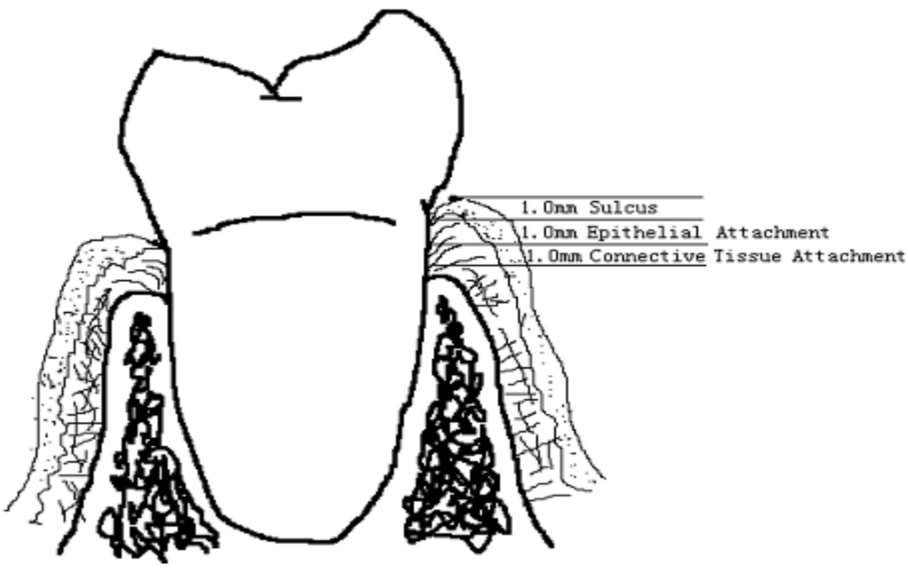
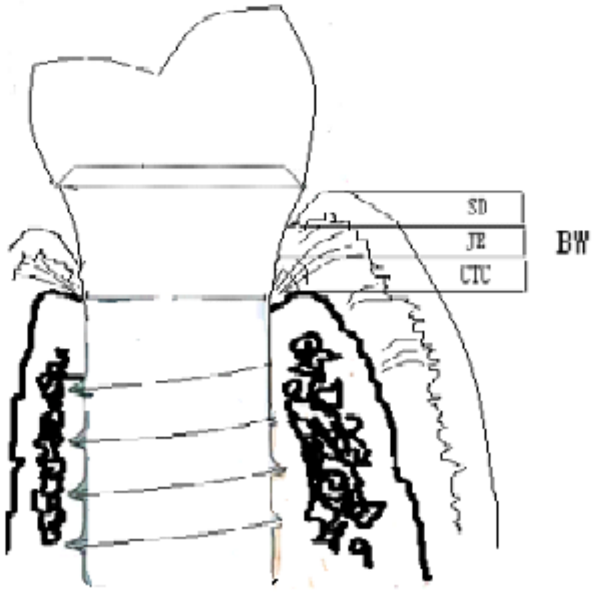


Figure 2: Biologic width of natural tooth

It became clear that the biologic width contributes to a “protection mechanism”. The function of which is to protect and maintain the dentoalveolar junction, an area susceptible to aggression from the oral environment [4]. The dimensions of the peri-implant mucosa was analyzed in a split mouth beagle dog study by Berglundh and Lindhe [48]. 2 mm long junctional epithelium and a zone of connective tissue of around 1.3 mm along the Brånemark implants was observed. It means that a minimum width of the peri-implant mucosa of around 3 mm may be required to prevent bone resorption and allow a stable soft tissue attachment to form. Cochran et al. described the biologic width around non-submerged one-piece dental implants and compared dimensions of the biologic width with that of natural teeth. The dimensions of the area of the biologic width, were similar to those of natural teeth, sulcus depth (0.16 mm vs 0.69 mm), junctional epithelium (0.97 mm vs 1.88 mm), connective tissue attachment (1.07 mm vs 1.05 mm), biologic width (2.04 mm vs 3.08 mm) for natural teeth and non-submerged implants respectively [49] (Figure 3). This physiological dimension was not altered whether loaded or unloaded. Berglundh et al. compared peri-implant soft tissue with the periodontium. Histologically, both the gingival and peri-implant tissues had a well keratinized oral epithelium which terminated at the crest of the gingival margin, and was continuous with an intrasulcular and junctional epithelium which faced the enamel or titanium surface. Peri-implant epithelium appeared to proliferate across post installation granulation tissue, in an apico-coronal direction creating the appearance of a junctional epithelium [4]. The presence of a basal lamina and hemidesmosomal adherence of junctional epithelium to the dental implant surface were described in some studies [50-52]. The majority of studies demonstrate connective tissue containing collagen fibres running mainly parallel to the dental implant, no vascular plexus, or high density venules are observed in the interface between the implant and the connective tissue, compared to the periodontium [4, 52-54]. Biologic width has also been determined a physiologically formed and stable structure which dimension is similar to the structure around a natural tooth [55].



SD:	Sulcus Depth
JE:	Junctional Epithelium
CTC:	Connective Tissue Contact
BW:	Biologic Width

Figure 3: Biologic width of implant

3.1.2. Bacteria infiltration

In-vitro and in-vivo, it was shown that in implant systems with screw-retained abutments, bacteria can penetrate into the internal cavity of the implant as a consequence of leakage at the implant-abutment interface [56-59]. Several studies have shown that for 2-piece implants, the bone crest level changes appeared dependent on the location of the interface between the implant platform and the abutment, if the interface was moved coronally away from the alveolar bone, less bone loss would occur but if the interface was located crestally or subcrestally, greater amounts of bone resorption were present [39, 60, 61]. Broggini compared the distribution and density of inflammatory cells surrounding implants with a supracrestal, crestal, or subcrestal interface at the connecting area of the implant platform and the abutment. Subcrestal interfaces promoted a significantly greater maximum density of neutrophils than did supracrestal interfaces, inflammatory cell accumulation below the original bone crest was significantly correlated with bone loss. Thus, the implant-abutment interface dictates the intensity and location of peri-implant inflammatory cell accumulation, a potential contributing component in the extent of implant-associated alveolar bone loss [40]. Hermann et al. found that the bone loss at the alveolar crest is significantly influenced by micro-movement between the platform and the abutment of the implant, but not by the micro-gap size of the interface between the implant platform and the abutment. This might be due to the fact that micro-movement enhances the flow of bacteria from and to the micro-gap with pumping like features, provoking the formation of an inflammation of the connective tissue in the region of the microgap and thus leading to bone resorption [42, 62]. Bone resorption will progress vertically and horizontally until the biologic width has been created and stabilized [20].

3.1.3. The mechanical factors

FEA can simulate the interaction phenomena between implants and the surrounding tissues. Analysis of the functional adaptation process is facilitated by the ability to investigate the various loading, implant, and surrounding tissue variables.

Bone resorption close to the first thread of osseointegrated implants is frequently observed after initial loading. The mechanism of bone resorption was also attempted to be explained by the mechanical stress at the bone-implant interface [63]. An example of a suspected bone morphology alteration due to stress is the apical migration of crestal bone down to the first thread of many implant systems [13, 31, 64]. It has also been hypothesized that the bone loss may slow down after the first thread when the force changes from crestal shear force to a compressive force induced by the thread itself [31]. Analyzing force transfer at the bone-implant interface is an essential step in the overall analysis of loading. Overload can cause bone resorption or even failure of the implant–bone interface, whereas lack of stress may lead to atrophy or even bone loss [65].

The load on an implant can be divided into a vertical and a horizontal component. Hansson postulated that, a conical implant–abutment interface at the level of the marginal bone, in combination with retention elements at the implant neck, and with suitable values of implant wall thickness and modulus of elasticity, the peak bone stresses resulting from an axial load arose further down in the bone. This meant that they were spatially separated from the peak stresses resulting from horizontal loads. If the same implant–abutment interface was located 2 mm more coronally, these benefits disappeared. This also resulted in substantially increased peak bone stress [66].

3.1.4. Design of the implant in the cervical region

Some implant types generally feature a smoothly polished cervical region. Hämmerle et al. placed the smooth conical cervical region of the conical implant below the bone level, the bone resorption occured down to the rough-to-smooth transition lone. These results were confirmed by Hermann et al and Hartman et al [32, 55, 67]. In a combined three－dimensional and axisymmetric finite element analysis study, Hansson calculated that a dental implant with retention elements all the way up to the crest can take more axial load than an implant with a smooth neck [9]. Nickenig et al. compared macro- and microstructure implant surfaces at the marginal bone level during a stress-free healing period and under functional loading. Radiographic evaluation of marginal bone levels adjacent to machined-neck or rough-surfaced microthreaded implants showed that implants with the microthreaded design caused minimal changes in crestal bone levels during healing (stress-free) and under functional loading [68]. Continuous microrough and nanorough titanium surface extending to the implant neck and a fine thread in the cervical region are the current trend [68-72].

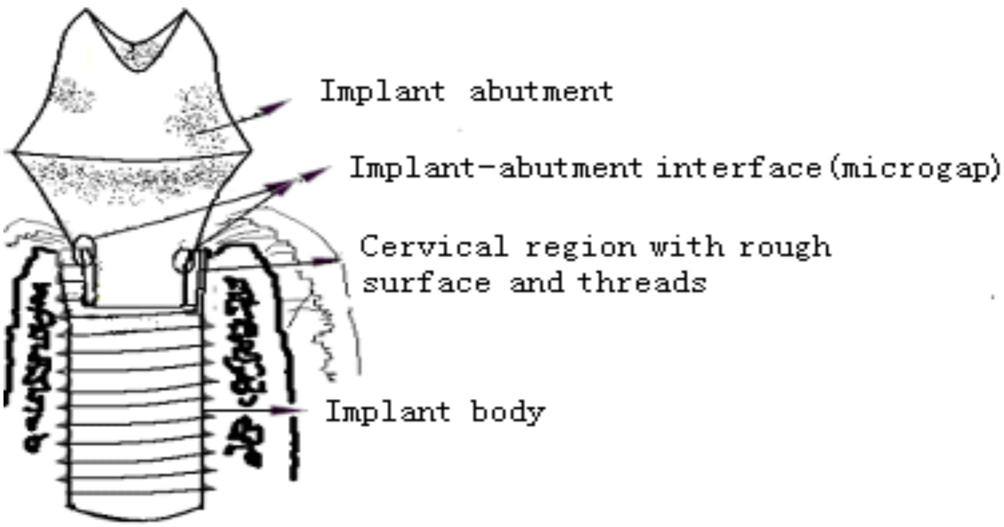


Figure 4: Region of the implant

3.1.5. Surgical trauma

Surgical trauma has been regarded as one of the commonly suspected factors proposed for the initial bone loss around the implant [31]. Heat generated at the time of drilling [73-75], elevation of the periosteal flap [76], and excessive pressure at the crestal region during implant placement may contribute to peri-implant bone loss during the healing period [77, 78].

3.1.6. The surface structure of the implants

The surface structure of the implants is said to influence the sustenance of osseointegration [79]. The surface structure of the implant is made up from nano-, micro- and macrostructure. The nanostructure refers to the chemical and biochemical properties of the implant surface and can influence cell function and orientation [80]. The microstructure refers to the chemical, mechanical or physical structuring of the surface [81]. The macrostructure refers to design elements including the thread, lacunae or pores. Studies have shown that the physical properties of the surfaces initially accelerate tissue reactions and influence processes such as cell adhesion and cell differentiation in the tissue surrounding the implant [82, 83]. Conditioned surfaces are distinguished from smooth titanium or titanium oxide surfaces. Ablative and additive processes are two methods to condition implant surfaces. The ablative processes include ablating techniques such as etching, for example with HCL/ H_2SO_4, blasting with various particles (Al_2O_3, sand, TiO_2) or a combination of the two (sand-blasted and acid-etched). That the implant surface is microstructured by additive techniques such as coating with hydroxyapatite or sintering nanoparticles are called additive processes. Compared with smooth implant surface，conditioned implant surfaces seem to promote active locomotion of pre-osteoblasts thus ensuring the intimacy of bone contact and enhancement of biomechanical interaction [84, 85]. In a human split-mouth study, compared with machined implants, the histological results showed greater average implant-bone contact rates with the dual etched surfaces after a six-month healing period [86]. Cho et al. found that by deposition of fibrin and osteogenic cells dual etched surfaces influence the osteoconductive process during healing [87]. In a study in minipigs，Buser et al. investigated the influence of the surface structure of different implant systems on bone integration. They found that conditioning implant surfaces with HCl/H2SO4 has a stimulating influence on bone apposition [6]. In the other experimental animal studies, greater bone-implant contact rates were found in dual etched implants compared with TitanPlasmaSprayed (TPS)-coated implants [88, 89]

3.2. Platform-switching: a new concept to reduce crestal bone resorption

The term platform switching refers to the use of a smaller diameter abutment on a larger diameter implant collar. This concept requires the alteration of the horizontal relationship between the implant diameter and the attached abutment diameter, to move the microgap between the implant and abutment away from the edge of the implant shoulder and closer toward the axis of the implant to increase the distance of the microgap to the crestal bone(Figure 5).

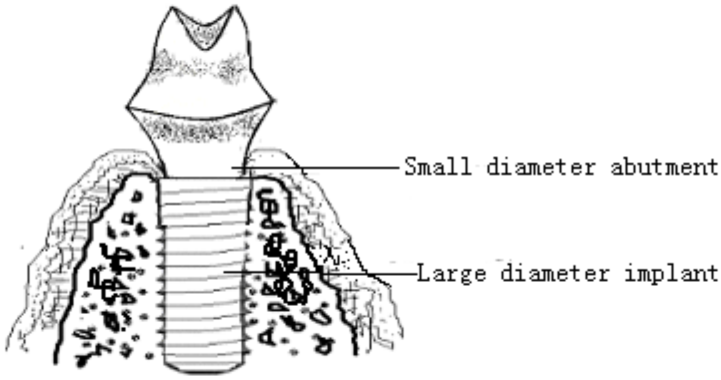


Figure 5: Platform-switching implant

In 1991, 3i used 4.1 mm diameter abutments to match 5 and 6 mm diameter implants and the control with matching platforms. After a 5-year period, less bone resorption is observed compared to the group of implants with matching-diameter abutment [90]. Vela-Nebot et al. compared the implants with matching implant-abutment (control) with platform-switched abutments (study). The mean values of bone resorption for the study group are significantly less than for the control group at 6 months after abutment attachment [91].

In a study using an animal model, it was found that implants with non-matching implant-abutment diameters demonstrated a smaller amount of bone loss [92]. In a mongrel dogs experiment, Weng et al. compared two types of implants (the internal Morse taper connection and platform-switching vs. the external hex connection and non-platform-switching) placed equicrestal and 1.5 mm subcrestal. After 6 months, histological findings discovered that the width and the steepness of the bone defect was less in platform-switching group than that in non-platform-switching group [93]. But in another study using the dog model, Becker et al. did not find a significant difference in crestal bone loss between implant groups with matching abutments and smaller-diameter abutments [94]. So further studies are still needed to clarify the influence of platform switching on crestal bone changes.

3D finite element analyses were also used to examine the biomechanical advantage of

platform-switching technique. It seemed that the platform switching model may reduce the shearing stress at the bone-implant interface area, which is most likely to cause disintegration [95]. A finite element analysis showed when the abutment diameter decreased, a reduction of stress at the crestal bone level accordingly after vertical and oblique loading occurred [96].
Gardner et al. and Lazzara et al. suggest platform-switching shifts the inflammatory cell infiltrate inward and away from the crestal bone, inducing a limitation of the bone resorption around the coronal aspect of the implant [97, 98].
Now there are different platform-switching implants available. They differ in their cervical designs and surfaces, as well as in the way their abutment is connected to the implant. We have implant-abutment connections refered to as conical or Morse-taper connections and butt-joint connections [99].
Within this study, we examined two implant systems, Wi.tal and Bone-level implants. They all allow platform-switching. Wi.tal implant is a parallelwalled screw implant designed in two parts, with the same internal connection for all diameters. The implant body is self-tapping and has an acid-etched surface called Osseo-Attract surface which extends as far as the implant platform but it has no threaded neck. The implant has a butt-joint connection (Figure 6, 7). The Bone-level implant has a cylindrical outer contour. The implant features a threaded neck. The implant body has a SLActive surface [100]. The implant has an internal conical implant-abutment connection (Figure 8, 9).

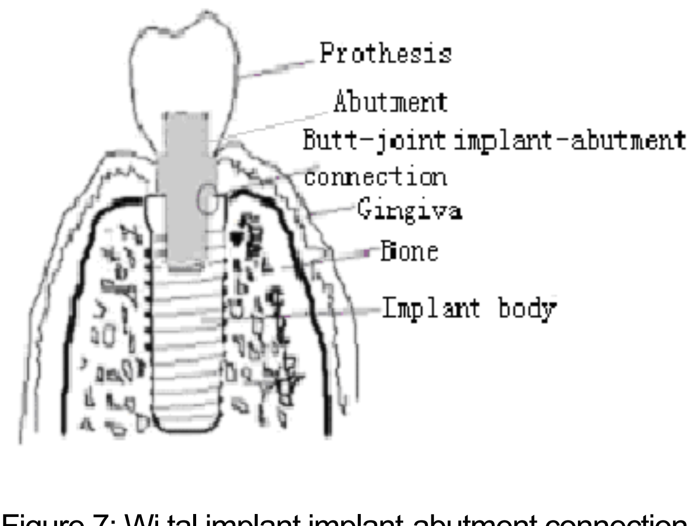


Figure 6: Wi.tal implant (Butt-joint connection)

Figure 7: Wi.tal implant implant-abutment connection

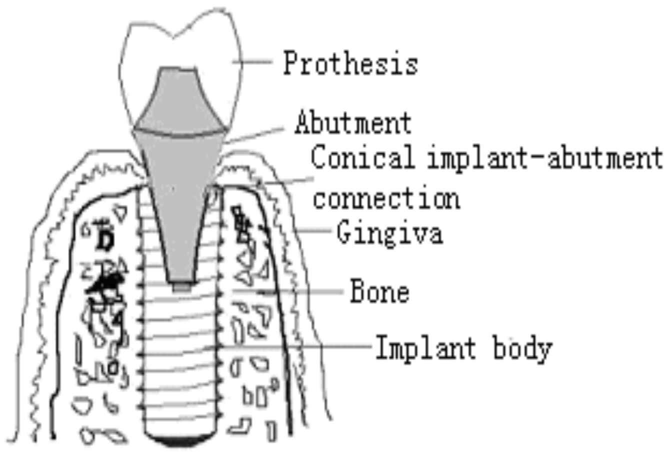


Figure 8: Bone-level implant (Conical connection)

Figure 9: Bone-level implant implant-abutment connection

3.3. Purpose

The purpose of this clinical radiologic evaluation study was to evaluate and compare the peri-implant bone loss around two platform-switched implants. One implant-system (Wi.tal implant) was a Butt-joint implant and one implant-system (Bone-level implant) has a conical implant-abutment connection.

4. Methodology

4.1. Patient selection and methods

From 2006 to 2009, 15 patients (male/female, 9/6) were consecutively registered and treated with Wi.tal implants or Bone level implants (1 patient was fully edentulous in both jaws, 6 patients were fully edentulous maxilla or mandible and 8 patients with 1-4 teeth lost), and then restored with fixed or removable implant-supported prostheses by two surgeons and two prosthodontists in the Department of Oral and Maxillofacial Surgery, Charite Campus Virchow, Berlin，Germany. A total of 45 implants were placed in the maxilla, mandible or in both jaws. Exclusion criteria as shown in Table 1 were used for patient selection.

- Uncontrolled diabetes
- History of leukocyte dysfunction or deficiency
- Metabolic bone disorders
- Alcoholism or drug abuse within the previous five years
- History of renal failure
- Untreated periodontitis
- Heavy smoking
- Severe bruxism
- Residual roots at the implant site
- Local inflammation or mucosal diseases such as oral lichen planus
- Patients at high risk for subacute bacterial endocarditis
- Liver dieases
- Immunocompromised patients
- Steroid treatment
- Current chemotherapy
- History of radiation treatment to head or neck
- Psychiatric contraindication
- Physical handicap that would interfere with the patient’s ability to exercise sufficient oral hygiene

Table 1: Exclusion criteria of patients.

The monitoring of all patients after implant placement was based on an established standard protocol (Table 2):

- Visual and digital inspection of prosthetic restoration and/or implants
- Random torque control of implant is performed
- Comparison with Buser criteria [16]

Table 2: Criteria evaluated during follow-up time

4.2. Implant system

Implant	Wi.tal(W)	Bone-level(BL)
Surface	OsseoAttract	Sandblasted large grit acid etched(SLActive)
Platform Dimension (mm)	4.3	4.1
Abutment Dimension (mm)	3.5	3.3
Implant length (mm)	11,13,15	10,12,14
Implant-abutment connection	Internal Butt-joint	Internal Morse-taper
Implant neck structure	Rough	Microthread Rough
Company	Wieland dental implant Gmbh Wiernsheim, Germany	Institut Straumann AG Basel, Switzerland

Table 3: Implant system

4.3. Surgical procedure

All implants were placed by 2 surgeons according to the manufacturer's protocol and with the use of a surgical template. Some patients were treated with local anesthesia using articaine with 1:100,000 epinephrine (Sanofi-Aventis, Frankfurt am Main, Germany). The others were treated in general anesthesia using TIVA (propofol/remifentanil). The details of the implants placed were registered in a specific dental record and comprised: brand, diameter and length. All implants were placed after raising a full-thickness mucoperiosteal flap. All implants healed submerged. The evaluation of the bone quality was made on the basis of tactile control through the operators [101]. Stabilization of the wound margins was performed with a recurrent suture technique. The sutures were Monocryl 5-0 (Ethicon Inc, New Jersey, U.S.A). The sutures were removed after 7-10 days. Second stage surgery was performed after the healing period. The implants were uncovered if necessary with local anesthesia with a crestal incision and a mucosal flap. The smallest healing abutments available were placed. The stability of the implant was evaluated with a torque control. Prosthetic rehabilitation was initiated when the torque value was $\geqq$35 Ncm. In cases with lower torque values, the implants were considered a failure. Torque values were assessed using an electronic torque controller (Intrasurg; Kavo, Biberach, Germany).

4.4. Prosthetic procedure

Existing removable dentures were immediately relined with a soft material (Softliner; GC, Tokyo, Japan) after implantation. Denture use was limited to esthetic use only during the first postoperative week. Conventional prosthetic steps were followed after the implants were uncovered. The implant-retained superstructures were classified in two groups: removable or fixed. All abutment screws were tightened with the torque specified by the implant manufacturer. Removable restorations include bar-retained or telescope retained versions. The bars and telescopes were fabricated using a high-gold alloy (Orplid TKF, Hafner, Pforzheim, Germany). Acrylic resin artificial teeth (Creapearl; Amann Girrbach, Pforzheim, Germany) were used. The prosthetic procedure for fixed restorations was carried out as described by Xiang et al [102]. The implant-retained fixed dentures were either vertically screwed directly onto the implant abutments or cemented on screw-tightened abutments using a provisional luting agent (ImProv, NobelBiocare, Sweden).

4.5. Radiologic evaluation

To quantify the amount of bone loss, measurements were performed using panoramic radiographs. Radiographs were taken at the following intervals:

1. On the day of implant placement (after operation).
2. At second-stage surgery.
3. On the day of prosthetic restoration.
4. Annualy thereafter.

All radiographs were taken using a standardized fixed position and identical digital X-ray technology (OPTG, Kodak 8000, Marne la Vallee Cedex 2, Frankreich; Orthophos XG 5/Ceph, Deutschland). Indistinct radiographs and those of unsuitable head positions were excluded from the study. The mesial and distal bone changes around the implants were measured with magnifying glasses (3.5×, Design for Vision Inc, Ronkonkoma, NY, USA). The measurement was carried out as described by Semper et al [103]. A specific reference point at the edge of the platform of the implant was used (Fig 10, 11). Measurements were made with a digital caliper with a maximum resolution of 0.01 mm (Holex, Hoffmann, Nürnberg, Modell, Deutschland). The vertical change of the marginal bone level was measured three times each at the mesial and distal aspects of implant. To eliminate radiographic distortions, values measured on the radiographs were adjusted by using the following method:

For each implant, the radiographic implant length was measured and divided by the actual implant length to determine the magnification factor for the correction of the radiographic system- inherent magnification. The bone loss in millimeters detected radiologically was divided by the magnification factor to obtain the actual bone loss. The edge of the implant platform was taken as a reference point, if the reference point below the alveolar crest, for example, the vertical distance was 5mm, we recorded -5mm; if the reference point above the alveolar crest, for example, the vertical distance was 5mm, we recorded 5mm; if the reference point at the alveolar crest, we recorded 0mm (Figure 10, 11).

The following measurements were taken and recorded for each of the radiographs in the study :

Mesial Bone Loss (MBL): The mesial vertical distance after follow up time minus that on the day of implant placement, in millimeters. Distal Bone Loss (DBL): The distal vertical distance after follow up time minus that on the day of implant placement, in millimeters.

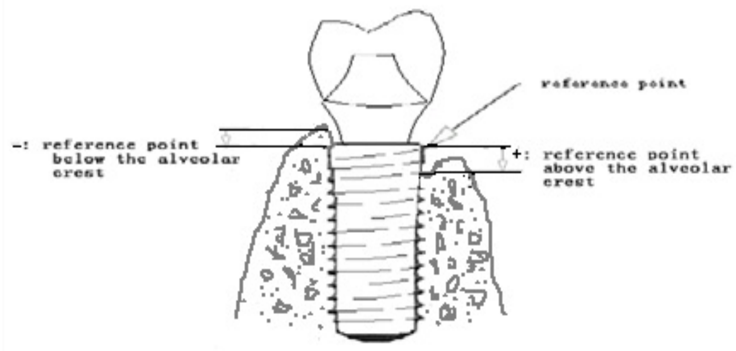


Figure 10: Bone-level implant

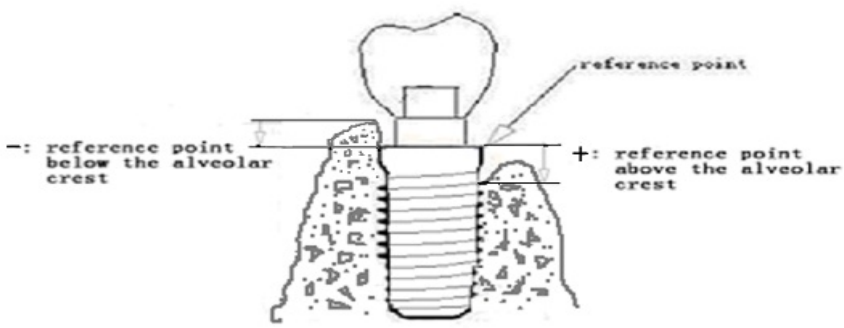


Figure 11: Wi.tal implant

一: reference point below the alveolar crest
＋: reference point above the alveolar crest
0 : reference point at the alveolar crest

4.6. Criteria of Success

An implant was considered successful if it fulfilled the criteria of Buser et al [16]:

- Absence of mobility of implant
- Absence of persistent subjective complaints such as pain, foreign body sensation and/or dysaesthesia
- Absence of a recurrent peri-implant infection with suppuration
- Absence of a continuous radiolucency around the implant

Table 4: Buser’s criteria on implant success

4.7. Statistical analysis

The amount of bone resorption over time between the two systems was analyzed by means of the Wilcoxon test. The criterion for statistical significance was set at $P<0.05$. Descriptive analysis was performed with all data available. Statistical analysis was accomplished using SPSS 13.0 for Windows.

5. Results

5.1. Characterization of patients and implants

From June 2006-September.2008, 15 patients with an average age of 61.8 (range: 48.6—72.3) year received a total of 45 implants. 24 Bone level implants and 21 Wi.tal implants were inserted. 8 patients (53.3 %) received Wi.tal implants (2 patients with fully edentulous maxilla or mandible, 1 patient was fully edentulous in both jaws and 5 patients with 1-4 teeth lost). 7 patients (46.7 %) received Bone-level implants (4 patients with fully edentulous maxilla or mandible, 3 patients with 2 teeth lost). 21 implants (46.7 %) were placed in the maxillary region, 24 implants (53.3 %) were placed in the mandibular region (Table 5, 6). The mean follow-up time was 14.8 (7-27) months. The Wi.tal implant group follow-up time was 17.8 (SD±5.3) months. The Bone-level implant group follow-up time was 12.3 (SD±4.6) months.

5.1.1. Implant distribution in the jaw

Wi.tal Implant distribution in the jaw (FDI)

position	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
No.of implants placed	0	0	0	0	1	1	0	0	0	0	1	2	1	1	0	0
position	38	37	36	35	34	33	32	31	41	42	43	44	45	46	47	48
No.of implants placed	0	0	1	2	3	3	1	0	0	0	2	2	0	0	0	0

Table 5: Wi.tal implant distribution in the jaw

Bone-Level Implant distribution in the jaw (FDI)

position	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
No.of implants placed	0	0	0	2	2	1	2	0	1	2	2	1	1	0	0	0
position	38	37	36	35	34	33	32	31	41	42	43	44	45	46	47	48
No.of implants placed	0	1	1	0	1	2	1	0	0	0	2	1	1	0	0	0

Table 6: Bone-Level implant distribution in the jaw

5.1.2. The implants parameters

In the Bone-level implant group, 4.1 mm diameter implants and 3.3 mm diameter abutments were used. In the Wi.tal implant group, 4.3 mm diameter implants and 3.5 mm diameter abutments were used. In both implant groups, the horizontal distance from the implant-abutment interface to the edge of platform are 0.4 mm.

Implant length	Wi.tal implant	Bone-level implant
10mm		5
11mm	11	
12mm		17
13mm	9	
14mm		2
15mm	1	
Total	21	24

Table7: The implant length distribution.

5.1.3. The average healing period

The average healing period before loading for the Bone-level implant group is 94.92 days and the Wi.tal implant group is 93.24 days.

5.1.4. Success rate

All implants fulfilled the Buser criteria [16], thus render a success rate of 100 %.

5.2. Radiographic Parameters

Adjusted values (explained on page19) were used to quantify crestal bone level changes around implants during follow-up time. The Values are given in Table 8+ Table 9.

Patient	Age	Gender	Region	IL	M1	D1	M2	D2	MBL	DBL	FU
	(year)			(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(month)
1	69.2	female	33	12	0	0	0.21	0.41	0.21	0.41	17
			34	12	0	0	0.41	0.52	0.41	0.52	17
			43	12	1.08	0.72	1.24	1.24	0.16	0.52	17
			44	12	0.35	0	0.56	0.66	0.21	0.66	17
2	63.8	male	32	12	0	0.34	1.19	1.41	1.19	1.07	19
			33	12	1.78	0	2.74	0.84	0.96	0.84	19
			43	12	0	0	1.29	0.54	1.29	0.54	19
			45	12	-0.37	-0.58	1.71	0.86	2.08	1.44	19
3	55.7	female	12	14	-1.2	-1.27	0.11	0.21	1.31	1.48	15
			22	14	-0.54	0	0.33	0.54	0.87	0.54	15
4	70.8	male	12	10	0	0	0.88	1.88	0.88	1.88	9
			13	10	0	0.15	2.1	2.47	2.1	2.32	9
			14	12	-0.54	0	0	0.82	0.54	0.82	9
			15	12	-0.68	-0.59	-0.35	0	0.33	0.59	9
			21	10	-0.58	-0.29	0	0	0.58	0.29	9
			23	10	-0.27	-0.2	0	0	0.27	0.2	9
			24	12	-0.22	0	0.82	0.58	1.04	0.58	9
			25	12	-0.47	0	0.45	1.46	0.92	1.46	9
5	51.4	female	36	12	0	0.2	0	0.81	0	0.61	8
			37	10	0	0	0.72	0.31	0.72	0.31	8
6	56.6	male	22	12	0.47	1.18	0.72	1.28	0.25	0.1	8
			23	12	0.73	0	0.87	0.28	0.14	0.28	8
7	53.6	female	14	12	0.3	0.7	0.8	1.1	0.5	0.4	8
			15	12	0.79	0.79	0.89	1.09	0.1	0.3	8

Table 8: Bone-level implant

Patient	Age (year)	Gender	Region	IL (mm)	M1 (mm)	D1 (mm)	M2 (mm)	D2 (mm)	MBL (mm)	DBL (mm)	FU (month)
1	71.3	m	13	11	0	0	0.87	0.87	0.87	0.87	22
			14	11	0	0	0.63	0.5	0.63	0.5	19
			24	11	2.19	2.02	2.44	2.39	0.25	0.37	19
2	66	m	33	13	0.24	0	1.71	2.25	1.47	2.25	17
			34	11	0	0	1.32	1.37	1.32	1.37	17
			43	15	0.41	0	2.44	2.33	2.03	2.33	17
			44	13	0.29	0	1.95	1.08	1.66	1.08	17
3	67.1	m	34	11	0.5	0.65	1.6	1.23	1.1	0.58	7
			35	11	0.55	0.53	0.86	1.2	0.31	0.67	7
			36	11	0.6	0.43	1.17	1.36	0.57	0.93	7
4	48.6	m	35	11	0.61	0	2.06	0.98	1.45	0.98	22
5	51.4	w	32	13	0.37	0.72	1.25	1.52	1.62	0.8	20
			33	11	0.43	0.42	1.52	2.81	1.09	2.39	20
			34	11	0.9	0.91	1.53	1.2	0.63	0.29	20
			43	13	1.07	1.53	2.35	2.26	1.28	0.73	20
			44	11	0.55	0.27	1.18	1.24	0.63	0.97	20
6	66.6	m	33	13	0	0.93	2.02	2.66	2.02	1.73	27
7	72.3	w	26	13	1.25	0	2.93	2.66	1.68	2.66	12
8	62.3	m	23	13	0.78	0.86	2.46	2.29	1.68	1.43	21
			24	13	1.04	1.01	2.3	2.31	1.26	1.3	21
			25	13	2.24	0.91	2.98	2.56	0.74	1.65	21

Table 9: Wi.tal implant

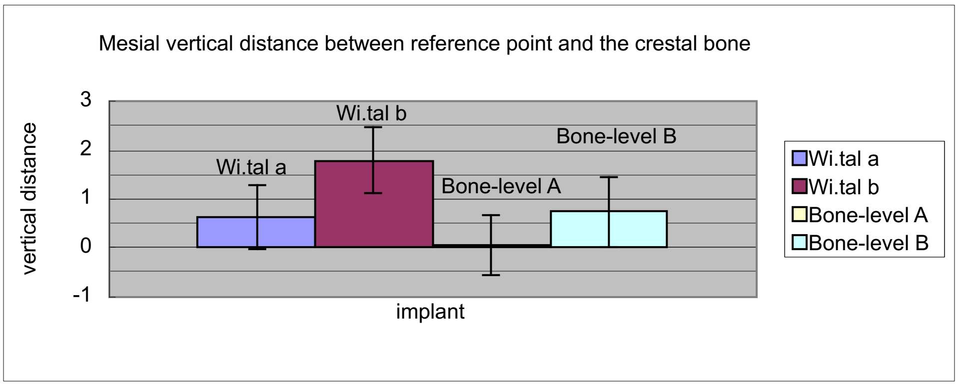
IL: implant length; M1: mesial vertical distance between reference point and the crestal bone on the day of implant placement; D1: distal vertical distance between reference point and the crestal bone on the day of implant placement; M2: mesial vertical distance between reference point and the crestal bone after follow up time; D2: distal vertical distance between reference point and the crestal bone after follow up time; MBL: mesial bone loss after follow up time; DBL: distal bone loss after follow up time; FU: follow up time (the time from the day of implant placement to the day of final measurement).

5.2.1. Crestal bone level (mean of mesial or distal vertical distance between the reference point and crestal bone) on the day of implant placement (after operation)

Mean of mesial vertical distance between the reference point and crestal bone on the day of implant placement is 0.63 mm (min: -0.37-max: 2.24 mm, SD±0.66 mm) in Wi.tal implants and 0.05 mm (min: -1.20-max: 1.78 mm, SD±0.62 mm) in Bone-level implants. Mean of distal vertical distance between the reference point and crest bone on the day of implant placement is 0.53 mm (min: 0.00-max: 2.02 mm, SD±0.57 mm) in Wi.tal implants and 0.03 mm (min: -1.27-max: 1.18 mm, SD±0.51 mm) in Bone-level implants (Figure 12, 13).

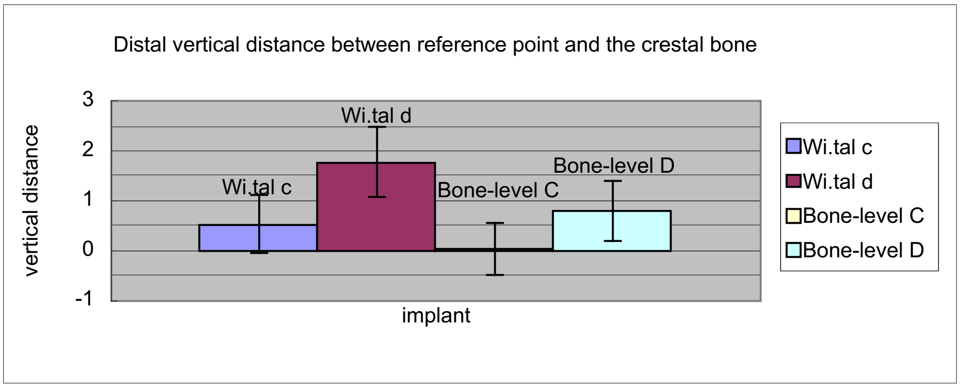
5.2.2. Mean of vertical distance between the reference point and the crestal bone after follow up time

These data are acquired after a mean follow-up time (17.8 months in Wi.tal implant group; 12.3 months in Bone-level implant group; 14.8 months in all implants). Mean of mesial vertical distance between the reference point and the crestal bone after follow up time are 1.79 mm (min: 0.63-max: 2.98 mm, SD±0.68 mm) in Wi.tal implants and 0.73 mm (min: -0.35-max: 2.74 mm, SD±0.72 mm) in Bone-level implants. Mean of distal vertical distance are 1.77 mm (min: 0.5-max: 2.81 mm, SD±0.71 mm) in Wi.tal implants and 0.80 mm (min: 0-max: 1.88 mm, SD±0.61 mm) in Bone-level implants (Figure 12, 13).



Wi.tal a: Mean of mesial vertical distance between the reference point and the crestal bone on the day of implant placement in Wi.tal implant group; Wi.tal b: Mean of mesial vertical distance between the reference point and the crestal bone after follow up time in Wi.tal implant group; Bone-level A: Mean of mesial vertical distance between the reference point and the crestal bone on the day of implant placement in Bone-level implant group; Bone-level B: Mean of mesial vertical distance between the reference point and the crestal bone after follow up time in Bone-level implant group.

Figure 12: Mean of mesial vertical distance on the day of implant placement and after follow-up time



Wi.tal c: Mean of distal vertical distance between the reference point and the crestal bone on the day of implant placement in Wi.tal implant group; Wi.tal d: Mean of distal vertical distance between the reference point and the crestal bone after follow up time in Wi.tal implant group; Bone-level C: Mean of distal vertical distance between the reference point and the crestal bone on the day of implant placement in Bone-level implant group; Bone-level D: Mean of distal vertical distance between the reference point and the crestal bone after follow up time in Bone-level implant group.

Figure 13: Mean of distal vertical distance on the day of implant placement and after follow-up time

5.2.3. The mean crestal bone loss

The mean of mesial crest bone loss are 1.16 mm (min: 0.25-max: 2.03 mm,SD±0.54 mm) in Wi.tal implant group and 0.73 mm (min: 0.00-max: 2.10 mm,SD±0.57 mm) in Bone-level implant group.

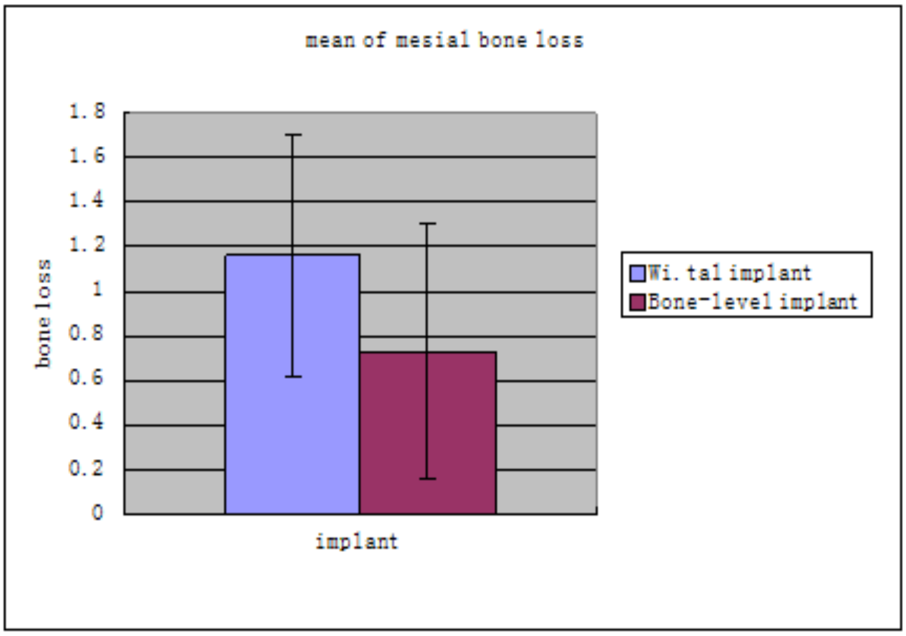


Figure 14: Mean of mesial crestal bone loss after follow-up time

The mean distal crestal bone loss after follow up time are 1.23 mm (min: 0.29-max: 2.66 mm, SD±0.70 mm) in Wi.tal implant group and 0.78 mm (min: 0.10-max: 2.32 mm, SD±0.56 mm) in Bone-level implant group.

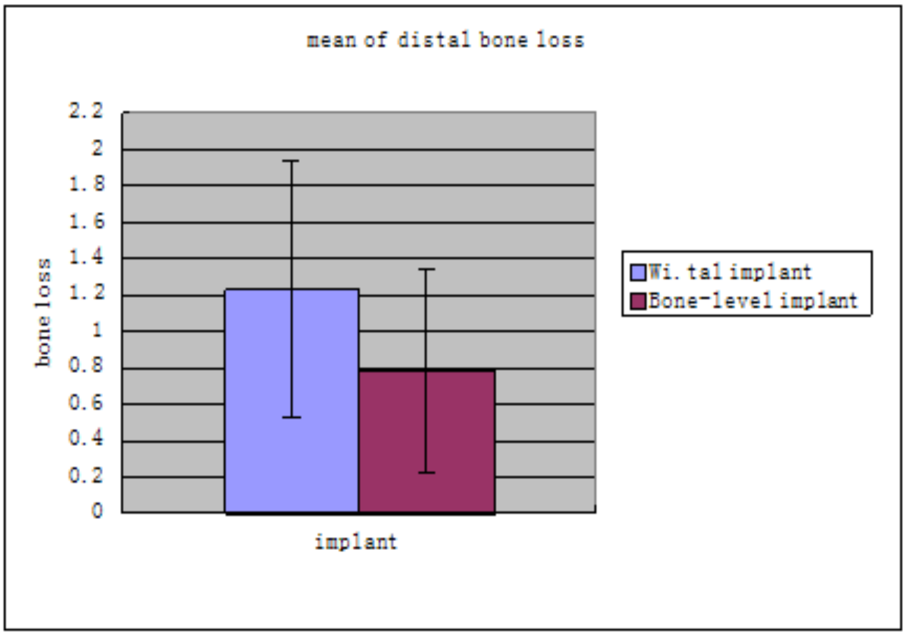


Figure 15: Mean of distal crestal bone loss after follow-up time

The mean crestal bone loss in all 45 implants (Wi.tal implant and Bone-level implant) after follow-up time are 0.93 mm (min: 0.00-max: 2.10 mm, SD±0.59 mm) mesial and 0.99 mm (min: 0.10-max: 2.66 mm, SD±0.66 mm) distal.

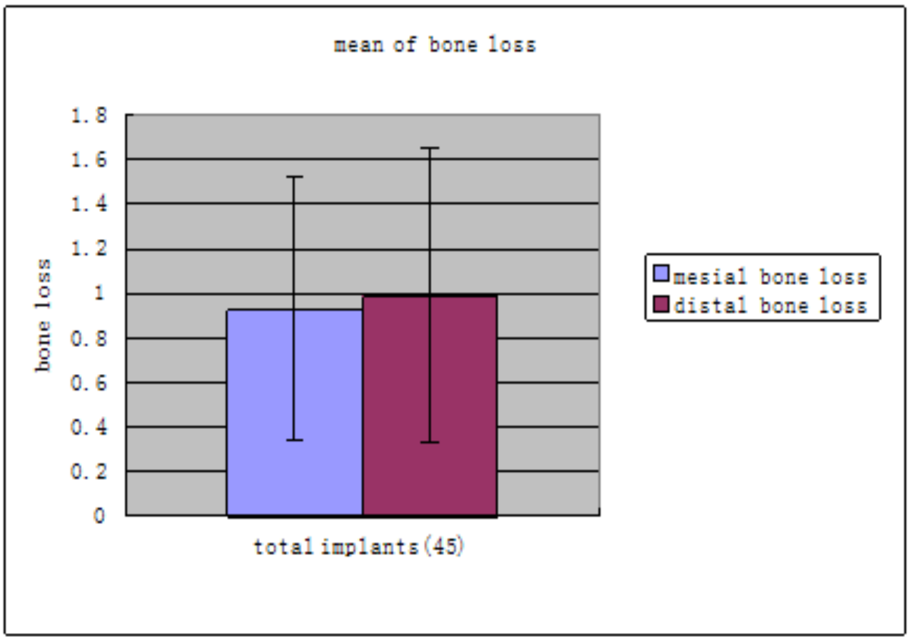


Figure 16: Mean of crestal bone loss in all 45 implants

The mean crestal bone loss are 1.25 mm (min: 0.31-max: 2.42 mm, SD±0.62 mm) in Wi.tal implant group and 0.73 mm (min: 0.18-max: 1.76mm, SD±0.54 mm) in Bone-level implant group.

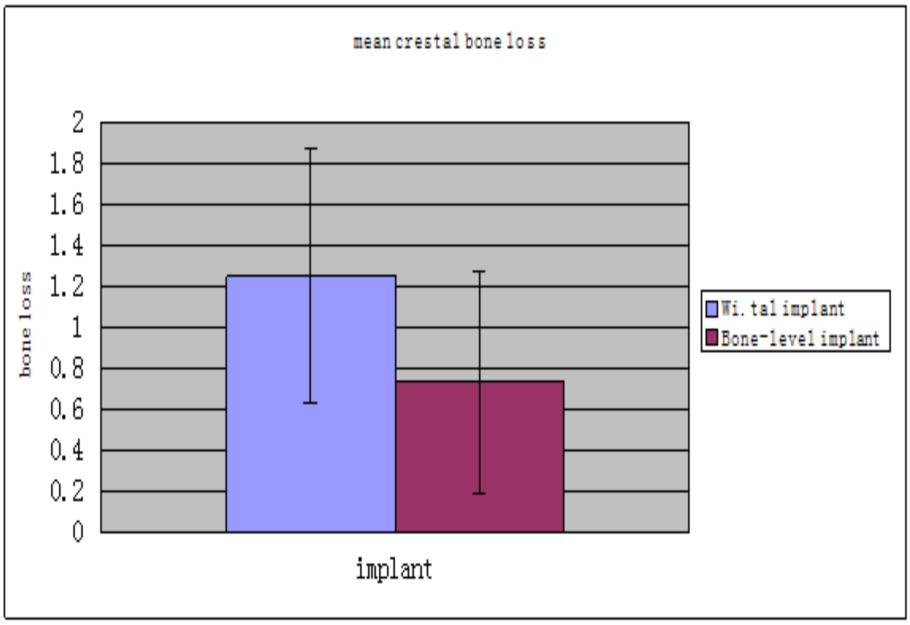


Figure 17: Mean of crestal bone loss in two implant groups

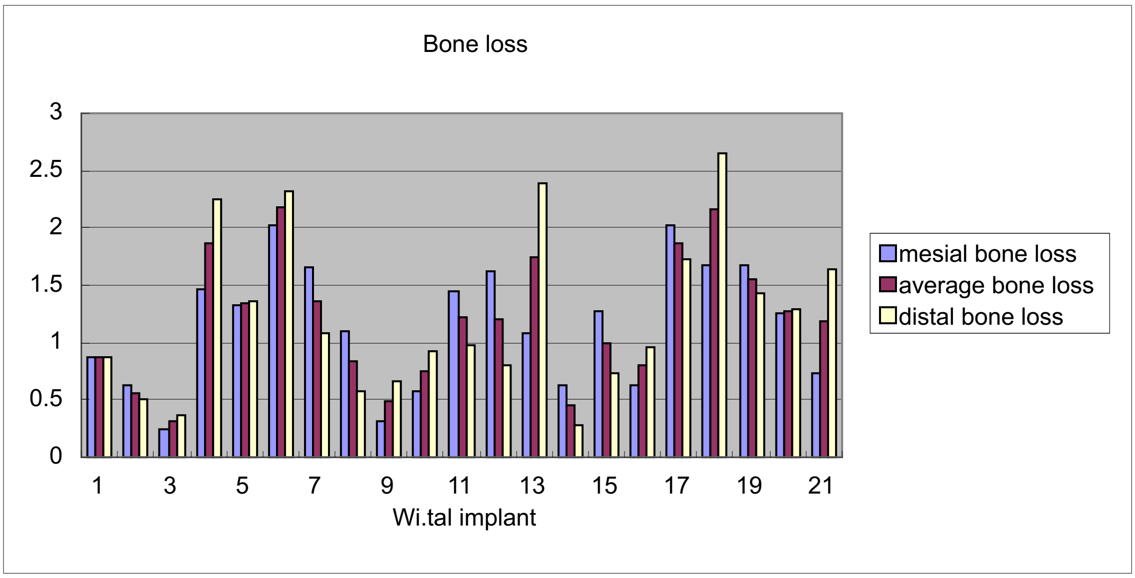


Figure 18: Bone loss in each Wi.tal implant

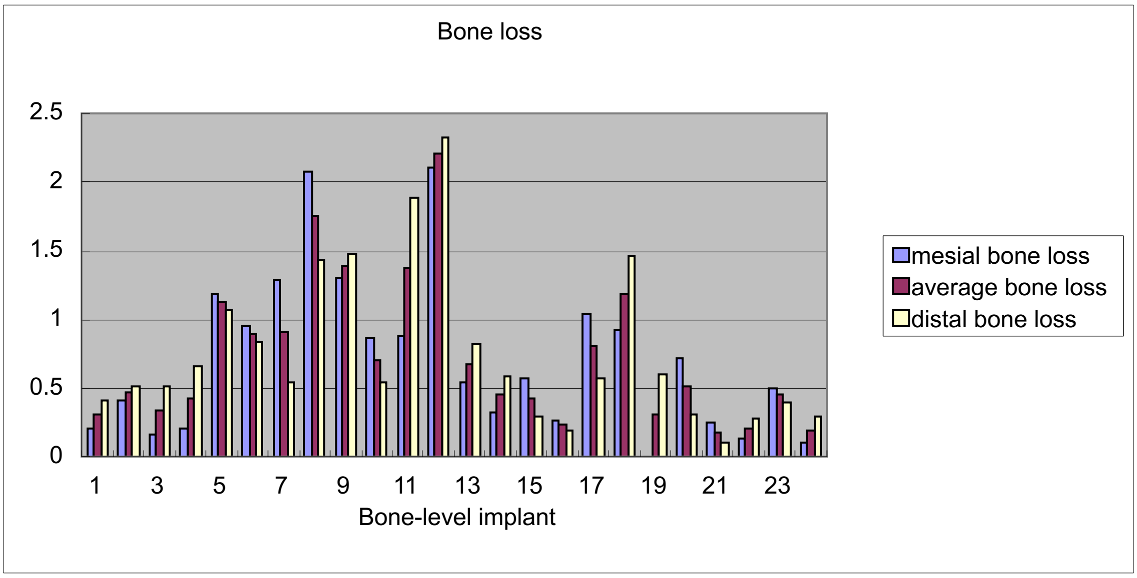


Figure 19: Bone loss in each Bone-level implant

5.2.4. The percentiles of mesial crestal bone loss in two implant systems

Percentiles of mesial bone loss	25%	50%	75%
Wital implant	<1.64 mm	<1.26 mm	<0.63 mm
Bone-level implant	<1.02 mm	<0.70 mm	<0.22 mm

Table 10: The percentiles of mesial crest bone loss after follow up time in two implant systems.

5.2.5. The percentiles of distal crestal bone loss in two implant systems

Percentiles of distal bone loss	25%	50%	75%
Wital implant	<1.69 mm	<0.98 mm	<0.70 mm
Bone-level implant	<1.01 mm	<0.59 mm	<0.40 mm

Table 11: The percentiles of distal crest bone loss in two implant systems.

5.2.6. The percentiles of crest bone loss in 45 implants

Percentiles of total implant bone loss	25%	50%	75%
mesial bone loss	<1.32 mm	<0.87 mm	<0.46 mm
distal bone loss	<1.44mm	<0.80mm	<0.52mm

Table 12: The percentiles of crest bone loss after follow up time in total 45 implants.

5.2.7. The Relationship between crestal bone level on the day of implant placement and crestal bone loss after follow up time

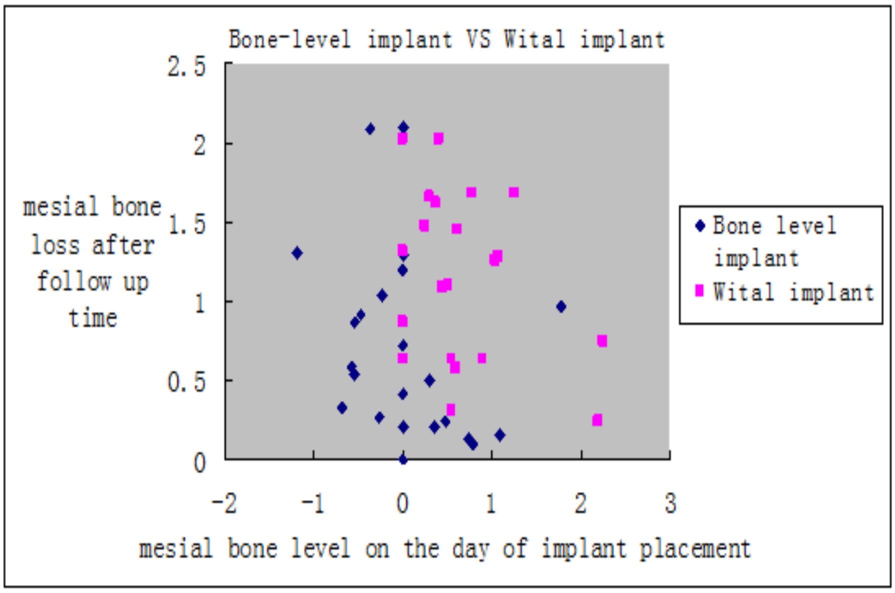


Figure 20: The scatterplot of relationship between mesial crestal bone level (vertical distance between the reference point and crestal bone) on the day of implant placement and crestal bone loss after follow up time

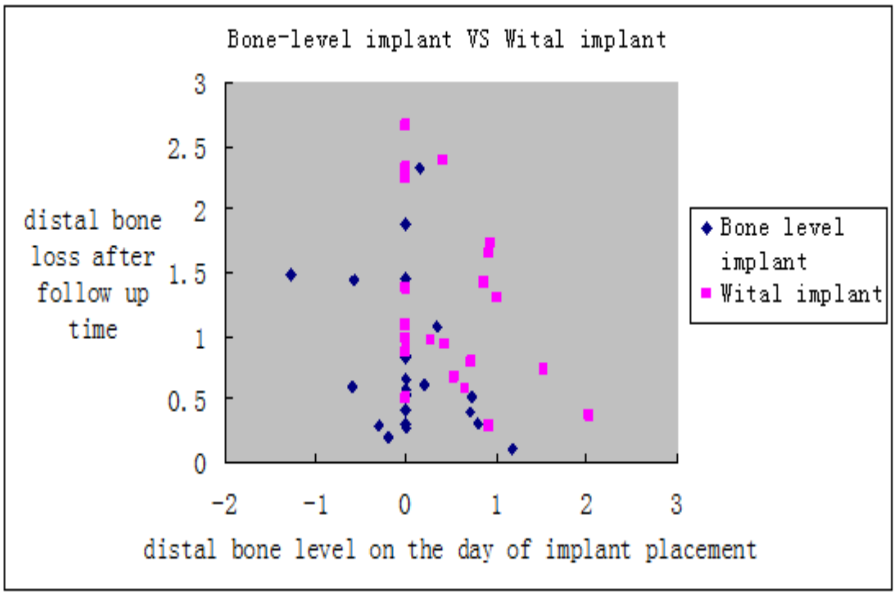


Figure 21: The scatterplot of relationship between distal crestal bone level (vertical distance between the reference point and crestal bone) on the day of implant placement and crestal bone loss after follow up time.

5.3. Two implant systems' panoramic x-ray picture

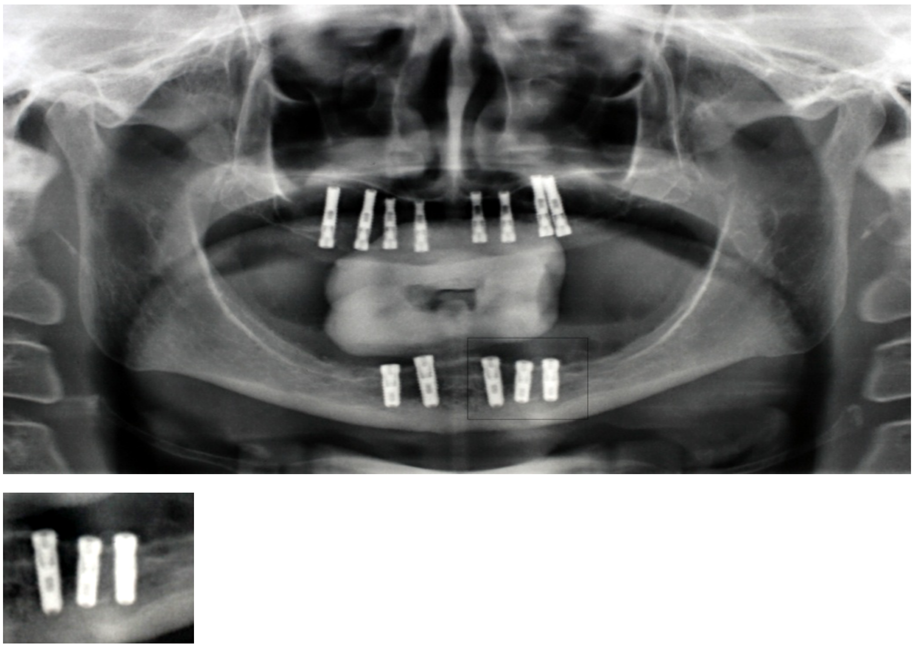


Figure 22: The panoramic x-ray picture at the time of Wi.tal implants placement

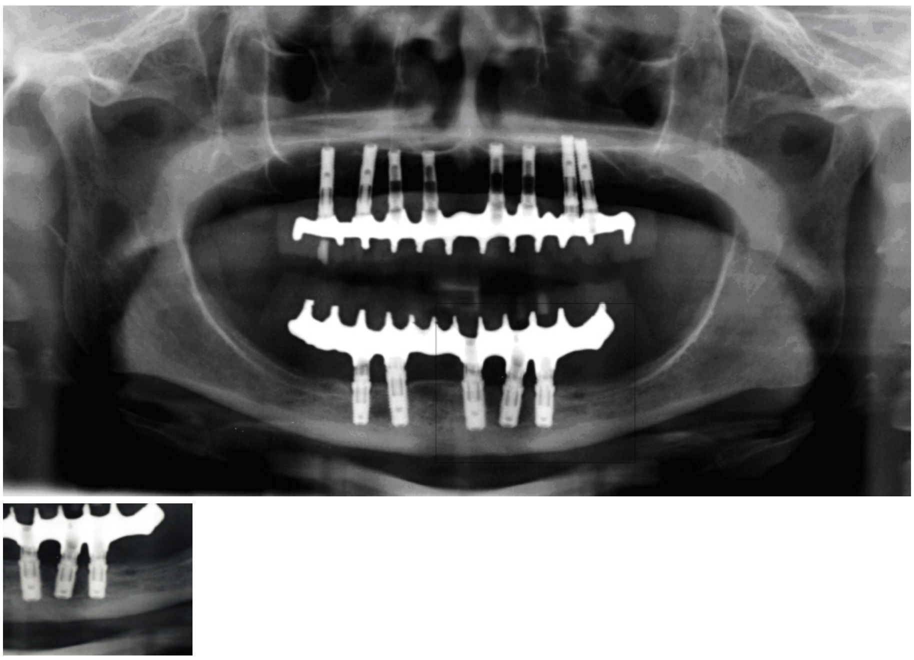


Figure 23: The panoramic x-ray picture one year after restoration (Wi.tal implant)

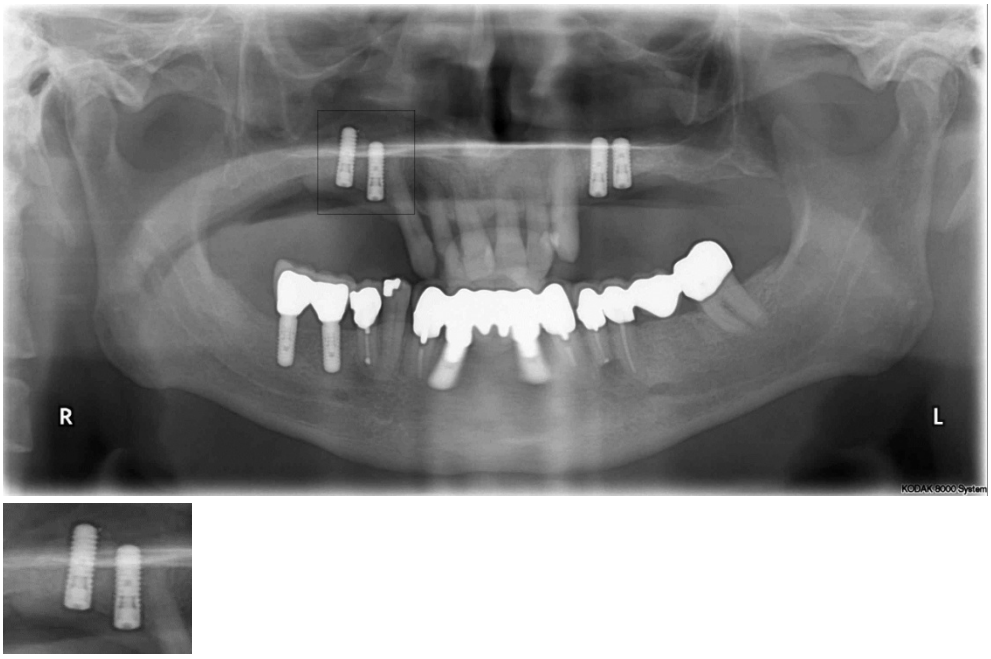


Figure 24: The panoramic x-ray picture at the time of Bone-level implants Placement

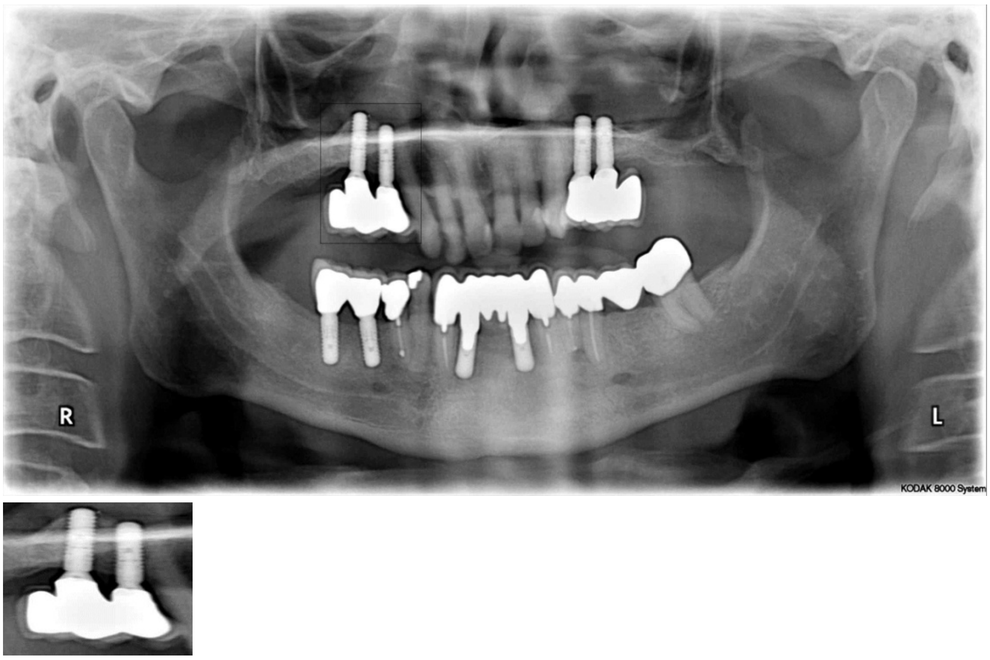


Figure 25: The panoramic x-ray picture one year after restoration (Bone-level implants)

5.4. Statistical Analyses

Wi.tal implant Versus Bone-level implant

The amount of bone resorption over time was analyzed by means of the Wilcoxon test. Between two implants groups, the Wilcoxon test shows that mesial and distal measurements differ significantly (all $P<0.05$). Therefore further statistical analysis was performed separately for the mesial and distal measurements. At the time of implant placement, the platform of the Wi.tal implants were placed more above the crest bone than that of the Bone-level implant ($p=0.002$ mesial; $p=0.004$ distal). After follow up time, the Bone-level implant group showed less bone loss than the Wi.tal implant group ($p=0.012$ mesial; $p=0.014$ distal).

6. Discussion

Accurate and reliable radiologic evaluation is required to assess bone levels proximal to oral implants. All radiographs in this study were taken with a standardized position and identical digital recording technology. The method to measure the peri-implant bone change is intraoral radiographs [104, 105]. Because of minimal variability, two-dimensional radiographs are reliable [30]. The panoramic exposure offers a shorter working time and ease of operation. For the assessment of the marginal bone level around teeth, Åkesson et al. concluded that the radiographic examination of choice should be the panoramic radiograph, which is in accordance with a study by Persson et al [106, 107] In assessing the point of bone attachment to implant threads, Kullman et al. concluded that panoramic radiographs were as reliable as conventional intraoral radiographs [108]. Zechner et al. compared intraoral radiographs with panoramic radiographs for their accuracy in evaluating peri-implant bone loss. They suggest that the two imaging techniques were comparable clinically in terms of the precision with which they could be used to measure marginal bone loss, panoramic radiographs can be a useful alternative to intraoral small-format radiographs for evaluating peri-implant bone loss [109, 110].

Peri-implant marginal bone loss is affected by one or more of the following factors: 1) a traumatic surgical technique [31]; 2) the shape, location, and size of the implant-abutment microgap and its microbial contamination [40, 42, 62, 93]; 3) the biologic width [111, 112]; 4) excessive loading [65]; 5) micromovements of the prosthetic components and implant [42, 62]; 6) the implant-neck geometry [32, 68]; 7) the infectious process [33]. In screw-type implants with matching diameter of the abutment and the abutment-platform interface adjacent to the bone crest, a peri-implant marginal bone loss (about 1.5 -2.0 mm) often occuring within the first year, up to or beyond the first thread has been documented [28, 64, 113-115]. If platform-switching helps reduce the amount of bone loss is still controversially discussed. Several studies showed that platform-switching can significantly reduce peri-implant crestal bone resorption [91, 116, 117]. However, some studies did not show a significant difference in crestal bone loss between the platform-switched and matched-diameter implants [118, 119].

The concept of platform switching is not fully understood, and several theories were suggested to explain this phenomenon. One theory assumed that shifting the implant-abutment connection may medialize the location of the biologic width and minimize the marginal bone resorption [98]. A study showed that placing the implant-abutment junction (IAJ) at or below the crestal bone level may cause vertical bone resorption to reestablish the biologic width [42], and an increased vertical distance of the implant-abutment interface relative to the bone crest reduces the amount of bone loss [40, 41, 69]. The biomechanical theory proposed that connecting the implant with a smaller-diameter abutment may decrease the crestal bone resorption by shifting the stress-concentration zone away from the crestal bone–implant interface and directing the forces of occlusal loading along the axis of the implant [95]. Reduced abutment diameter (i.e., platform switching) resulted in less stress translated to the crestal bone [96]. It is hypothesized that two-piece implant that allow platform-switching increases the distance between the abutment-associated inflammatory cell infiltrate and the marginal bone level, and thereby might decrease the marginal bone loss [93, 98, 120-122].

This study, based on radiographic analysis of implants, evaluate the effect of two different types of platform-switching on two-piece implant at the marginal bone level during functional loading. To our knowledge, this is the first clinical study to assess marginal bone loss between two platform-switching implant systems with different platform-abutment connections (Morse taper connection Vs Butt joint connection). In Wi.tal implant group, the mean crest bone loss were 1.16 mm (mesial) and 1.23 mm (distal). In Bone-level implant group, the mean crestal bone loss was 0.73 mm (mesial) and 0.78 mm (distal), the mesial (p=0.012) and distal (p=0.014) crestal bone loss was significantly different between Wi.tal and Bone-level implants. The Bone-level implant group showed less bone loss than the Wi.tal implant group.

It is said that an increased vertical distance of the implant-abutment interface relative to the bone crest may reduce the amount of bone loss [40, 41, 69]. Hermann et al. reported, for the 2-piece implant, the amount of crestal bone loss around implant is associated with the location of the implant-abutment interface. Placing the interface in a location apical to the crestal bone result in greater bone loss [55]. Jung et al. revealed crestal bone loss increased with the implants placed below the bone crest [120]. Which is in concordance with the findings in the present study showing a higher bone loss in implants placed subcrestally. In this study, as shown in the scatter graphs (Figure 12, 13, 20, 21), when the platform of the implants was placed at the bone crest, or above bone crest, the amount of bone loss during the follow up time was smaller than that implants placed subcrestally, crestal bone loss increases with the distance of the implant shoulder below the bone crest. So it does seem important to keep the distance between the implant-abutment interface and the crestal bone surface. But between the Wi.tal implant group and Bone-level implant group, the horizontal distance from the implant-abutment interface to the edge of platform is the same (0.4 mm), the Bone-level implant shoulder was placed more apical to the crestal bone but resulted in less bone loss. For the Wi.tal implant, compared to the Bone-level implant, supracrestal placement of implant shoulder did not prevent bone loss.

Peri-implant marginal bone loss may be affected by several factors.One possibility to influence the bone change is the type of connection and platform design (butt-joint connection Vs internal Morse-taper design). Theoretically, a high value of the interfacial shear stress implies an abrupt load transfer whereas a moderate interfacial shear stress signifies a gradual load transfer into the bone. When the interfacial shear stress exceeds the interfacial shear strength, bone fracture and relative movements or bone resorption can be expected to occur [123-125]. Different implant-abutment interfaces induce different interfacial shear stress. It is suggested that the implant-abutment interface be designed in such a way that the peak bone-implant interfacial shear stress caused by an axial load is reduced and does not land at the very attachment level where the implant starts to interlock with the bone, but deeper down. A flat top interface of the design is hypothesized to give rise to unnecessarily high peak bone-implant interfacial shear stresses. In contrast, a conical implant-abutment interface seems to give rise to moderate peak interfacial shear stresses and a more favorable peak stress location [126-128]. Palmer et al. observed high marginal bone levels using an implant characterized by a conical implant-abutment interface and a conical neck that is provided with a thread of small dimensions and roughened by means of blasting with titanium dioxide. The load from the abutment is transmitted to the inner conus of the implant. The marginal bone stabilizes close to the level of the implant-abutment interface [129]. In the present study, it seems that the implant connection type of the Wi.tal implant group (Butt joint connection) exerts a more pronounced influence on the periimplant bone than the connection type of the Bone-level implant group (Morse taper connection).The cervical surface structure of the implant maybe an additional factor that affects the bone loss around dental implants. The Wi.tal implant has a microrough neck whereas the Bone-level implant features microrough neck and a thread to the top for extensive interlocking with the bone. When an oral implant is occlusally loaded, the highest stress is transferred to the most coronal portion of the supporting bone [130, 131]. Hermann et al. concluded that a fine thread in the cervical region results in functional loads being transmitted to the adjacent bony structures, supporting the formation of trabecular bony structures and stabilizing the region. In a reduced-bone environment, the fine thread around the implant neck may help to stabilizes the implant in the presence of an underprepared osteotomy (implant bed preparation), contributing to the achievement of primary stability. In turn, it may help to reduce the length of time for the healing phase [71].

The importance of the present study is the measurement of actual crestal bone loss around implant from the day of implant placement till the end of follow-up time. Most of platform-switching studies consider the distance between the shoulder of implant platform and bone-implant contact as crestal bone loss after follow up time, but without measuring the initial crestal bone height (bone above the platform shoulder or below the platform shoulder) on the day of implant placement. In a study of platform-switching implant, the mean crestal bone loss 12 months after loading is 0.95 mm. The shoulder of implant platform was placed subcrestaly. The bone loss measurements were made from the shoulder of implant platform to the first bone-implant contact. But the bone loss above the platform was not considered [116]. Vigolo et al. reported that the mean crestal bone loss around platform-switched implant is 0.6 mm in an over 5-years period study, but the authors still did not consider the bone loss above the platform [132]. No radiograph pictures were given to assess the crestal bone height around the platform of the implant on the day of implant placement in Wagenberg et al. study [117]. Some studies did not consider the crestal bone loss in the healing period. Hürzeler et al. reported, one year after restoration, mean crest bone loss were 0.1 mm ±0.4 mm for the test group (14 wide-diameter implants supplied with platform-switched abutments) and 0.3 mm±0.3 mm for the control group (8 implants with regular diameter supplied with regular abutments) [133]. But the comparison between the two studies is not adequate as the bone loss during the healing and prosthetic restoration period is ignored. Vela-Nebot et al. reported a mean value of bone loss of 0.8 mm in the mesial measurement and 0.8 mm in the distal measurement. But the follow-up time was short (6 months after abutment attachment) and in some implants, also the bone loss before the abutments attachment were ignored [91]. In the mentioned studies, no attention or radiographic pictures were made to record and assess the crestal bone height around the platform of implants on the day of implant placement and the crestal bone loss in the healing period was ignored. So it is not adequate to make an accurate comparison between the present study and other studies, because of the different time points of measurement. The mean crestal bone loss in Wi.tal implant after 17.8 months follow-up time is 1.25 mm and it is 0.73 mm in Bone-level implant after 12.3 months follow-up time. In the present study, we have stated that in some cases, on the day of implant placement, the crestal bone level was coronal to the implant platform, we assess the coronal bone loss above the implant platform during healing period, after abutment attachment and implant loaded.

Also it was observed that the magnitude of the marginal bone level changes among the studies are different, this may be due to different factors, i.e. different implant geometry, follow up time, study population, implant-abutment diameter difference, loading protocol.

Platform-switching does not always reduce the amount of bone loss. Using a implant with a conical implant abutment connection (Bone-level implant) seems to reduce amount of bone loss. Supracrestal placement of the implant with a butt-joint connection + platform-switching did not prevent bone loss. Subcrestal placement of the conical implant-system resulted in more crestal bone loss compared to supracrestal placement. Crestal bone loss was seen in both implant systems. It still needs further studies to clarify the influence of platform switching on crestal bone changes.

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8. Abbreviations

1. Bone-level A: mean of mesial vertical distance between the reference point and the crestal bone on the day of implant placement in Bone-level implant group
2. Bone-level B: mean of mesial vertical distance between the reference point and the crestal bone after follow up time in Bone-level implant group
3. Bone-level C: mean of distal vertical distance between the reference point and the crestal bone on the day of implant placement in Bone-level implant group
4. Bone-level D: mean of distal vertical distance between the reference point and the crestal bone after follow up time in Bone-level implant group
5. BW: biologic width
6. CTA: connective tissue attachment
7. CTC: connective tissue contact
8. DBL: distal bone loss
9. D1: distal vertical distance between the reference point and the crestal bone on the day of implant placement
10. D2: distal vertical distance between the reference point and the crestal bone after follow up time
11. FDI: federation dentaire internationale
12. FEA: finite element analysis
13. FU: follow up time
14. JE: junctional epithelium
15. IAJ: implant-abutment junction
16. IL: implant length
17. MAX: maximum
18. MBL: mesial bone loss
19. MIN: minimum
20. M1: mesail vertical distance between the reference point and the crestal bone on the day of implant placement
21. M2: mesial vertical distance between the reference point and the crestal bone after follow up time

22. NY: New York
23. P: probability
24. SD: sulcus depth
25. SD: standard deviation
26. SLActive: sandblasted large grit acid etched
27. SPSS: statistical product and service solutions
28. 3D: three dimension
29. TIVA: total intravenous anesthesia
30. TPS: titanplasmasprayed
31. USA: United States of America
32. Wi.tal a: mean of mesial vertical distance between the reference point and the crestal bone on the day of implant placement in Wi.tal impant group
33. Wi.tal b: mean of mesial vertical distance between the reference point and the crestal bone after follow up time in Wi.tal implant group
34. Wi.tal c: mean of distal vertical distance between the reference point and the crestal bone on the day of impant placement in Wi.tal implant group
35. Wi.tal d: mean of distal vertical distance between the reference point and the crestal bone after follow up time in Wi.tal implant group

Affidavit

“I, [LiBo He] certify under penalty of perjury by my own signature that I have submitted the thesis on the topic [Radiographic evaluation of crestal bone level changes around implants and abutment with non-corresponding diameters: A prospective pilot study] I wrote this thesis independently and without assistance from third parties, I used no other aids than the listed sources and resources.

All points based literally or in spirit on publications or presentations of other authors are, as such, in proper citations (see "uniform requirements for manuscripts (URM)" the ICMJE www.icmje.org) indicated. The sections on methodology (in particular practical work, laboratory requirements, statistical processing) and results (in particular images, graphics and tables) correspond to the URM (s.o) and are answered by me. My interest in any publications to this dissertation correspond to those that are specified in the following joint declaration with the responsible person and supervisor. All publications resulting from this thesis and which I am author correspond to the URM (see above) and I am solely responsible.

The importance of this affidavit and the criminal consequences of a false affidavit (section 156,161 of the Criminal Code) are known to me and I understand the rights and responsibilities stated therein.

Date 7/31/2014 Signature

Curriculum Vitae

My curriculum vitae does not appear in the electronic version of my paper for reasons of data protection.

Complete list of publication

No publication

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