Platform-Switched Restorations on Wide-Diameter Implants: A 5-year Clinical Prospective Study

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Purpose: *The purpose of the present investigation was to clinically assess and compare crestal bone changes, over a 5-year period, around external-hexagon wide-diameter implants restored with either matching wide-diameter prosthetic components or with platform-switched prosthetic components.* ***Materials and Methods:*** *During the years 2000 to 2002 all patients who received a single 5-mm-diameter implant with an external hexagon in a private office setting were included in this study. All implants were placed in the posterior areas of the jaws. Maxillary left molars (group A1) and mandibular right molars (group A2) were restored with matching wide-diameter prosthetic components; maxillary right molars (group B1) and mandibular left molars (group B2) were restored with platform-switched prosthetic components. Marginal bone resorption was measured via intraoral radiographs each year after abutment and crown insertion. Statistical analyses were used to determine whether there was a significant difference in marginal bone levels with respect to the width of prosthetic components used.* ***Results:*** *In all, 182 single 5-mm-diameter implants were placed in 144 patients and all implants survived. Eighty-five implants were restored with matching wide-diameter prosthetic components (group A), and 97 implants were restored with platform-switched prosthetic components (group B). A significant difference in marginal bone levels was found between group A and group B implants after 1 year. The mean marginal bone resorption was 0.9 mm (SD 0.3 mm) for group A implants and 0.6 mm (SD 0.2 mm) for group B implants. Marginal bone resorption observed at the second, third, fourth, and fifth years after abutment and crown insertion did not show any significant change.* ***Conclusion:*** *Statistically significant differences in marginal bone loss were observed between study groups. The 85 implants restored with matching wide-diameter prosthetic components showed more bone loss than the 97 implants restored with platform-switched prosthetic components.* Int J Oral Maxillofac Implants 2009;24:103–109

Key words: *dental implants, implant diameter, platform switching*

Marginal bone loss around various types of implants has been described during the first year of loading and in subsequent years of service.[1–5] This initial peri-implant bone loss has been attributed to numerous possible factors, such as surgical trauma,[6] peri-implantitis,[7,8] occlusal overload,[9–12] biologic width formation,[13,14] implant macroscopic and microscopic characteristics at the neck region in contact with bone,[2,15–18] implant-abutment interface design,[19,20] and position of the microgap.[14,21] The amount of peri-implant marginal bone loss has also been found to be time-related, with significantly more acute bone loss during the preloading period than in the following loading phases (up to 24 months after surgery) and also during the first year after loading (6 to 12 months after surgery) than in the second one (12 to 24 months postsurgery).[22,23]

Prevention of horizontal and vertical marginal peri-implant bone resorption during the postloading period is fundamental in maintaining stable gingival levels and profiles around implant-supported restorations.[24] There is an association between the preservation of bone and the preservation of soft tissue around implants. Some authors have proposed methods to maintain supporting bone, for example,

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Table 1 Implant and Restoration Data for Single-Tooth Edentulous Sites

Location	No. of implants	Type of rehabilitation
Maxillary left molars	42	Matching wide-diameter prosthetic components (group A1)
Maxillary right molars	50	Platform-switched prosthetic components (group B1)
Mandibular right molars	43	Matching wide-diameter prosthetic components (group A2)
Mandibular left molars	47	Platform-switched prosthetic components (group B2)

improved implant necks and different abutment-to-implant configurations.[18,20,25,26] In a recent article, the concept of platform switching, based on anecdotal clinical observations that bone resorption does not occur when the interface between the implant shoulder and abutment is moved horizontally away from the bone, has been hypothesized.[24] The authors suggested the combination of implants with smaller-sized abutments for this purpose. The reduced marginal peri-implant bone loss with platform switching may be the result of distancing the contaminated microgap between implant and abutment away from the bone.[24] A recent article observed that, at the introduction of wide-diameter implants in 1991, matching-diameter prosthetic components were not available, such that many of the wide-diameter implants were restored with standard-diameter (4.1-mm) prosthetic components.[27] The authors stated that long-term retrospective radiographic follow-up of these "platform-switched" restored wide-diameter implants demonstrated a smaller than expected vertical change in the crestal bone height around these implants than was typically observed around implants restored conventionally with prosthetic components of matching diameters. The authors suggested that, by repositioning the implant-abutment junction inward and away from the outer edge of the implant and adjacent bone, the overall negative impact of the abutment inflammatory cell infiltration on the surrounding tissue as described by other authors[28–30] may be reduced, thus decreasing its resorptive effect on crestal bone.

From a biomechanical perspective, stress is concentrated around the crestal region when two materials with different moduli of elasticity (bone and implant) are placed together, as demonstrated in photoelastic and finite element analysis studies.[31] Peak bone stresses that appear in marginal bone have been hypothesized to cause bone microfracture[32] and may be responsible, at least in part, for peri-implant bone loss with saucerization patterns after prosthetic loading.[31] The issue of whether platform switching may affect stress patterns by minimizing peak bone stresses in the marginal bone has not been investigated.

The purpose of this prospective investigation was to clinically assess crestal bone changes around external-hexagon wide-diameter implants restored with matching wide-diameter prosthetic platforms and to compare these to the changes seen around external-hexagon wide-diameter implants restored with platform-switched prosthetic components.

MATERIALS AND METHODS

During the years 2000 to 2002 all patients who received a single 5-mm-diameter implant with an external hexagon (3i/Implant Innovations, Palm Beach Gardens, FL) in a private office setting were included in this study according to the following criteria:

1. Lack of systemic contraindication for oral surgical therapy
2. Single-tooth edentulous sites in the mandibular and maxillary molar regions
3. Presence of adequate bone width precluding the need for bone augmentation procedures

The patients' ages ranged from 25 to 55 years (mean age, 37). All single wide-diameter implants were surgically placed by the same practitioner with the use of a surgical template. Implants were selected to be restored with matching wide-diameter prosthetic components or with platform-switched prosthetic components: maxillary left molars (group A1) and mandibular right molars (group A2) were restored with matching wide-diameter prosthetic components, and maxillary right molars (group B1) and mandibular left molars (group B2) were restored with platform-switched prosthetic components (Table 1).

The study was approved by the Clinical Medical Ethical Committee of the Italian Dental Association. The consent of patients was obtained prior to implant placement. All implants were placed at the bone crest level, and radiographs were made to demonstrate the bone level at the time of implant placement (see later text for description of the standardization protocol). The apical end of the smooth

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collar of the implants was considered the coronal reference point. At second-stage surgery, 4 months after placement of the implants, matching wide-diameter titanium healing caps (WTH54, 3i/Implant Innovations) were connected on groups A1 and A2 implants, and platform-switched titanium healing caps (THA54, 3i/Implant Innovations) were connected on groups B1 and B2 implants. Radiographs were made and showed similar bone levels at the time of implant uncovering between all groups. The master impression was made 3 weeks after second-stage surgery. For the impression phase, 2-mm-thick custom impression trays were fabricated with Palatray LC resin (Heraeus Kulzer, Wehrheim, Germany), in accordance with the manufacturer's instructions. The impression trays had one window to allow access for the coping screws and had been previously coated with tray adhesive (Dental-Medizin; ESPE, Seefeld, Germany). Prior to each impression procedure, a matching wide-diameter square impression coping (pick-up type; WIP55, 3i/Implant Innovations) was secured to the groups A1 and A2 implants, and a platform-switched square impression coping (pick-up type; IIC12, 3i/Implant Innovations) was secured to the groups B1 and B2 implants. An elastomeric impression material (Impregum Penta; ESPE) was machine-mixed (Pentamix; ESPE), and a standard impression technique was accomplished.

A wide-diameter implant replica (ILAW5; 3i/Implant Innovations) was connected to the impression coping for each group A1 and group A2 implant, and a platform-switched replica (ILA20; 3i/Implant Innovations) was connected to the impression coping for each group B1 and group B2 implant. The impression was poured with Type IV stone (New Fujirock; GC Corporation, Tokyo, Japan). All laboratory procedures were performed by the same technician, and all prostheses were provided by the same prosthodontist.

For the implants selected to be restored with matching wide-diameter prosthetic components (groups A1 and A2), wide-diameter gold UCLA-type abutments (SWGA51C, 3i/Implant Innovations) were used. For the implants selected to be restored with platform-switched prosthetic components (groups B1 and B2), standard-diameter gold UCLA-type abutments (SGUCA1C, 3i/Implant Innovations) were used. Both types of gold alloy abutments were screwed to implant replicas using waxing posts, and wax was added directly to the gold cylinders following standard waxing procedures. The waxed cylinders were then invested in a carbon-free phosphate-bonded investment (Ceramicor; Cendres et Métaux, Biel-Bienne, France) and cast using a noble alloy (Esteticor Plus; Cendres et Métaux; composition: gold 45.0%, palladium 38.9%, silver 5.0%, indium 8.6%). The custom abutments were screwed to implants clinically with Gold-Tite screws (3i/Implant Innovations) and torqued to 32 Ncm (Torque Driver CATDO; 3i/Implant Innovations). Porcelain-fused-to-metal definitive crowns with porcelain occlusal surfaces were fabricated for all abutments. A noble alloy (Esteticor Plus; Cendres et Métaux SA) was used for the metal copings and porcelain was added (Noritake EX-3; Noritake, Nagoya, Japan). All custom abutments were prepared by the technician with a chamfer preparation line, and all porcelain fused-to-metal definitive crowns had a 0.4-mm-thick circumferential metal margin. All definitive restorations were provisionally cemented (Temp Bond NE, Kerr Italia, Scafati, Salerno, Italy).

Radiographic assessments were performed during all prosthetic phases (impression phase, abutment try-in, final try-in). For esthetic reasons, the crown/abutment margin was placed 1 mm subgingival on the buccal surfaces for both types of abutments; the crown/abutment margin was always placed at the gingival level on the mesiodistolingual surfaces, where esthetics were not a concern. Careful handling was done during the laboratory phase to prevent further contamination of the abutment surfaces.[33] Within all groups, the occlusal surfaces of the restorations were designed to avoid premature contacts during lateral and protrusive movements. Canine guidance was the preferred occlusal scheme for all cases.

A follow-up recall included patient assessments every 3 months during the first year and every 6 months in subsequent years. All patients regularly returned to the office for recall appointments, and all implants under investigation have been accounted for. The implant survival was judged on the following criteria[34–36]:

- Absence of mobility
- Absence of painful symptoms, discomfort, altered sensation, paresthesia, or infection attributable to the implants
- Absence of peri-implant radiolucency during radiographic evaluation
- Absence of progressive marginal bone loss (mean vertical bone loss < 0.2 mm annually following the first year of function)

Radiographs were made at each assessment. During the 5 years following prosthetic rehabilitation, disconnection and reconnection of the abutments were avoided to prevent bone loss, as described in previous animal studies.[29] Periapical radiographs were taken every 12 months for each implant using

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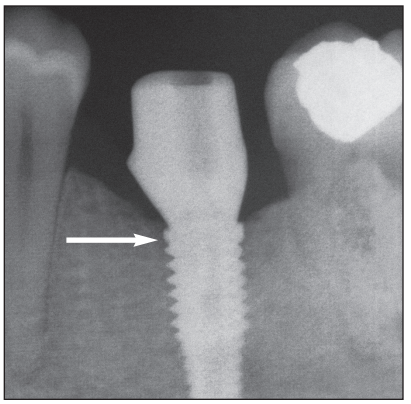


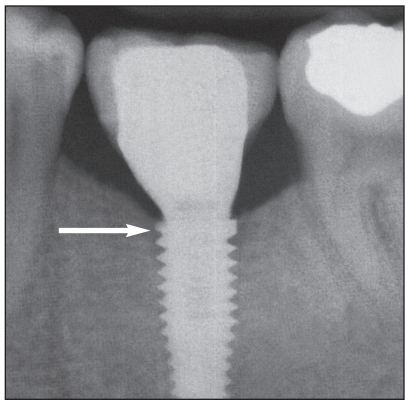
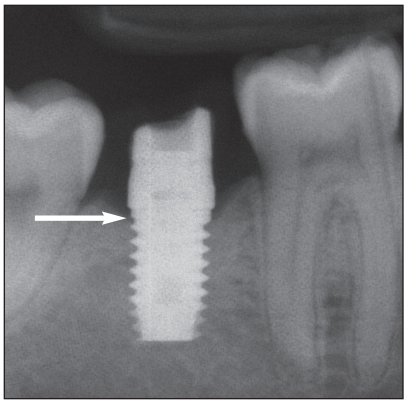


Fig 1 *(left)* Radiograph of a wide-diameter implant restored with platform-switched prosthetic components at the time of abutment placement (the apical end of the smooth collar of the implant was considered the coronal reference point; *arrow*).

Fig 2 *(right)* Wide-diameter implant restored with platform-switched prosthetic components at 5 years after abutment placement (*arrow* = coronal reference point).



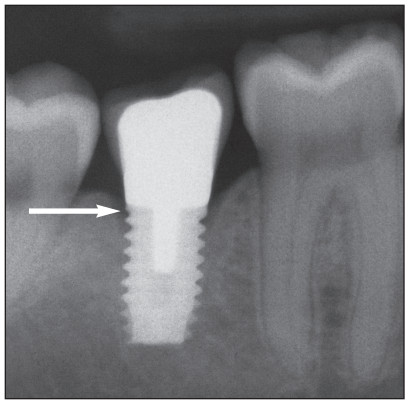


Fig 3 *(left)* Wide-diameter implant restored with matching wide-diameter prosthetic components at the time of abutment placement (*arrow* = coronal reference point).

Fig 4 *(right)* Wide-diameter implant restored with matching wide-diameter prosthetic components at 5 years after abutment placement (*arrow* = coronal reference point).

an individual stent and the long-cone technique; this was done to control imaging geometry by consistently placing the films at a standard distance from the x-ray cone, parallel to the long axis of the implant and perpendicular to the central ray, and allow for standardization of consecutive radiographs, as suggested by previous studies.[37-41] The radiographic films were evaluated using a 6× magnifying lens, which permitted the measurement of marginal bone resorption with an accuracy of ± 0.2 mm. The initial measurement of the marginal bone level, taken with the same standardized intraoral radiographic method, was recorded as baseline at the time of abutment and crown insertion. The apical end of the smooth collar of the implants was considered the coronal reference point (Figs 1 to 4). All radiographic measurements were carried out by the same blinded operator. Intraoperator variability was assessed using 10 repeated measurements of the bone levels for one selected implant in each of the groups (A1, A2, B1, and B2) at time 1 (1 year after abutment and crown insertion).

The Mann-Whitney *U* test and the two-sample Kolmogorov-Smirnov test were used to determine whether there was a statistically significant difference in peri-implant marginal bone levels between the implants restored with matching wide-diameter prosthetic components (groups A1 and A2) and the implants restored with platform-switched prosthetic components (groups B1 and B2).

RESULTS

The study had a 100% subject retention rate. All 182 implants survived the second surgical phase and loading with definitive restorations. No patient reported any prosthetic complications, such as loosening of the custom screwed abutment, fracture of the porcelain, or loosening of provisionally cemented definitive crowns. Bone quality at the implant sites was estimated at the time of implant placement. There was not any difference in bone quality between groups A1 and A2 and groups B1 and B2. Seventy-three implants were placed in type 1 bone, 68 implants were placed in type 2 bone, and 41 implants were placed in type 3 bone.[42]

Relative to intraoperator variability, the standard deviations of the 10 repeated measurements were 0.1 mm for the selected implants of groups A1, A2, B1, and B2. These small standard deviations indicate acceptable reliability of the measurement method.

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Table 2 Marginal Bone Resorption (mm) During the 5-Year Study Period

Group	Time 1	Time 2	Time 3	Time 4	Time 5
A1 (n = 42)	0.9 ± 0.3	1.0 ± 0.3	1.0 ± 0.3	1.1 ± 0.3	1.2 ± 0.3
A2 (n = 43)	0.8 ± 0.2	0.9 ± 0.3	0.9 ± 0.3	1.0 ± 0.3	1.0 ± 0.3
A overall (n = 85)	0.9 ± 0.3	1.0 ± 0.3	1.0 ± 0.3	1.1 ± 0.3	1.1 ± 0.3
B1 (n = 50)	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2
B2 (n = 47)	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2
B overall (n = 97)	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2

The mean marginal bone resorption at the first year after abutment and crown insertion, as measured with the intraoral radiographic examination method[37–39] from the apical end of the smooth collar of the implants, was 0.9 mm (SD 0.3 mm) for group A1 (42 maxillary implants restored with matching wide-diameter prosthetic components) and 0.8 mm (SD 0.2 mm) for group A2 (43 mandibular implants restored with matching wide-diameter prosthetic components). The mean marginal bone resorption was 0.6 mm (SD 0.2 mm) for group B1 (50 maxillary implants restored with platform-switched prosthetic components) and 0.5 mm (SD 0.2 mm) for group B2 (47 mandibular implants restored with platform-switched prosthetic components). The mean marginal bone resorption was 0.9 mm (SD 0.3 mm) for all group A implants (A1 + A2) and it was 0.6 mm (SD 0.2 mm) for all group B implants (B1 + B2). Statistical analysis revealed a significant difference between group A (A1 + A2) and group B (B1 + B2) ($P < .05$). The data on marginal bone resorption collected at the second, third, fourth, and fifth years after abutment and crown insertion did not show any significant changes (Table 2).

DISCUSSION

Peri-implant marginal bone loss has been demonstrated to occur shortly after loading, up to or beyond the first thread of titanium screw-type implants for external-hexagon implants. There is a relationship between the preservation of bone and the preservation of soft tissue around implants. Recently, platform switching, a technique that is based on anecdotal clinical observations that bone resorption does not occur when the interface between the implant shoulder and abutment is moved horizontally away from the bone, has been hypothesized to reduce early bone loss around implants.[24,27] In the present clinical investigation, a statistically significant difference was detected in crestal bone changes between wide-diameter implants restored with matching wide-diameter prosthetic components (group A) and wide-diameter implants restored with platform-switched prosthetic components (group B). These implants were evaluated radiographically for 5 years following prosthodontic rehabilitation with respect to peri-implant marginal bone levels. After 12 months of function, the group B implants showed less bone loss than the group A implants. The data did not change during the following 4 years of function.

The comparison of these two types of restorations on wide-diameter implants with respect to peri-implant marginal bone levels revealed clinically significant differences in outcomes at the end of the evaluation period. No patients reported any prosthetic complications. Patients were young (the ages ranged from 25 to 55 years, with a mean age of 37), in good health, motivated, and always returned to the scheduled control appointments. No loosening of the abutment screws was found with the crowns cemented on either group. Accurate evaluation of the occlusal scheme and the provision of appropriate variations in the occlusal contacts, both static and dynamic, may also explain the lack of prosthetic complications, such as porcelain fracture and loosening of provisionally cemented definitive crowns. Canine guidance was the preferred occlusal scheme for all patients. The occlusal surfaces of the posterior restorations were designed to avoid premature contacts during lateral and protrusive movements.

For esthetic reasons, the crown/abutment margins were not placed too deeply in the gingiva. For both types of abutments, the crown/abutment margin was placed 1 mm subgingivally on the buccal surfaces; on the mesiodistolingual surfaces, where esthetic concerns did not exist, the crown/abutment margin was placed at the gingival level. Furthermore, it should be noted that the cemented crowns of both groups required particular attention to the removal of all subgingival cement at the cementation phase to minimize problems associated with peri-implant gingival tissues. A provisional cement without eugenol (Temp Bond NE) was used to permit easier removal of the cemented crowns if needed.

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One limitation of this study may be represented by the measurement technique used in the research protocol. Accurate and reliable measurement methods are required to assess bone levels proximal to oral implants.[38] All radiographs in this study were taken with a standardized film holder. This device was designed to control imaging geometry by consistently placing the films at a standard distance from the x-ray cone, parallel to the long axis of the implant and perpendicular to the central ray. The radiographic films were then evaluated using a 6× magnifying lens. However, in a previous study, the microscope-assisted measurement technique of standardized radiographs was compared to the computer-assisted measurement technique. The computer technique showed low intraoperator and interoperator variability, and operators found fewer "unreadable" sites compared to the microscope technique.[41]

Within the limitations of the present investigation, namely the small number of patients studied and the use of only external-hexagon implants, findings were similar to those of previous studies.[24,27] Platform switching appears to be a viable method for preserving crestal bone around the top of wide-diameter implants and seems to alter the starting point from which crestal bone remodeling occurs. Whether this phenomenon can be attributed to distancing the contaminated microgap from the first bone-to-implant contact or to minimizing peak bone stresses in the marginal bone still has to be investigated. It should be noticed that in this research 5-mm-diameter implants with an external hexagon were used. In the literature, there is no evidence of dissimilar marginal bone resorption when regular-platform implants are restored with matching-diameter prosthetic components or with narrower prosthetic components. It should also be noted that other implant systems (eg, ITI/Straumann, Astra Tech) have different configurations of the implant/abutment interface, so that the mechanical relationship between the implant itself and the prosthetic component cannot be compared to the implant/abutment interface of an external-hexagon implant system. This may result in different tissue responses not influenced by the concept of platform switching. Jansen et al stated that all two-stage implant systems leave gaps and cavities between implant and abutment that can act as traps for bacteria and thus possibly cause inflammatory reactions in the peri-implant soft tissues.[43] In their study, 13 different implant-abutment combinations were subjected to an in vitro experiment in which the penetration of bacteria (*Escherichia coli*) was observed in 10 assemblies of each type. All implant systems presented microbial leakage. The conical abutment design used in the Astra Tech and ITI/Straumann systems showed tolerances as low as 1 to 2 µm, compared to 5 to 10 µm for the other systems evaluated. The decreased microbial leakage at the implant/abutment interface would probably result in less crestal bone resorption with these implant systems.[43,44]

CONCLUSIONS

Within the limits of this study, the following conclusions may be drawn:

1. Statistically significant differences in marginal bone loss were observed between the four study groups in the first year; implants restored with matching wide-diameter prosthetic components (groups A1 and A2) showed more bone loss (0.9 mm; SD 0.3 mm) compared to the implants restored with platform-switched prosthetic components (groups B1 and B2) (0.6 mm; SD 0.2 mm).
2. The data on marginal bone resorption collected at the second, third, fourth, and fifth year after abutment and crown insertion did not show any significant change between the four study groups.

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