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Influence of platform switching on crestal bone changes at non-submerged titanium implants: a histomorphometrical study in dogs

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Abstract

Objectives: The aim of the present study was to investigate histomorphometrically the influence of platform switching on crestal bone changes at non-submerged wide-body titanium implants in a dog model.

Material and Methods: One-stage insertion of sand-blasted and acid-etched screw-type implants with either matching (CAM) or smaller-diameter healing abutments (CPS) were randomly assigned to the lower jaws of nine beagle dogs. The animals were killed after 7, 14, and 28 days of non-submerged healing. Dissected blocks were processed for histomorphometrical analysis. Measurements were made between the implant shoulder (IS) and: – the apical extension of the long junctional epithelium (aJE), – the most coronal level of bone in contact with the implant (CLB), and – the level of the alveolar bone crest (BC).

Results: At 7, 14, and 28 days, the mean IS–aJE values were significantly the lowest at CPS implants. However, after 28 days of healing, both groups revealed significantly increased mean IS–BC values at the buccal aspect of the alveolar bone. The difference in IS–CLB and IS–BC between groups was not significant.

Conclusions: Within the limits of the present study, it was concluded that both CAM and CPS implants revealed crestal bone-level changes after 28 days of healing.

Key words: animal study; histomorphometry; marginal bone level; platform switching

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Nowadays, there is considerable evidence supporting the view that the replacement of missing teeth by means of endosseous titanium implants has become a predictable treatment modality for both completely and partially edentulous patients (Jemt et al. 1996, Lindquist et al. 1996, Buser et al. 1997, Lambrecht et al. 2003). Comparable treatment outcomes were reported for both submerged (Brånemark et al. 1969) and non-submerged healing procedures (Ericsson et al. 1994, Henry & Rosenberg 1994, Bernard et al. 1995, Becker et al. 1997, Collaert & De Bruyn 1998). Previous experimental animal studies have indicated that the transmucosal attachment revealed a junctional epithelium and connective tissue, resulting in a 3–4 mm wide zone of biological soft tissue coverage of the implant-supporting bone (Berglundh et al. 1991, Abrahamsson et al. 1996, 1998, Berglundh & Lindhe 1996). The formation of peri-implant tissues was not dependent on the surgical approach (Abrahamsson et al. 1996, Ericsson et al. 1996, Weber et al. 1996). During the first year of loading, however, particularly two-piece implants were

Conflict of interest statement and source of funding

The authors (J. B., D. F., M. H., F. S.) declare that they have no conflict of interests. The co-authors (A. K., A. S.) provided an experimental implant design. Dr. Schaer is an employee of Camlog Biotechnologies AG, the manufacturer of the tested implant systems.

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frequently associated with crestal bone changes of about 1.5–2.0 mm (Albrektsson et al. 1986, Smith & Zarb 1989, Jung et al. 1996). Furthermore, previous results from an experimental animal study have indicated that remodelling and resorption following implant placement was more pronounced at the buccal than at the lingual aspect of the alveolar bone crest (Botticelli et al. 2004). Accordingly, in recent years, several investigations have been carried out in order to explain these changes in crestal bone height. In particular, some authors discussed a potential role of the microgap at the implant–abutment interface in bacterial colonization of the implant sulcus (Mombelli et al. 1987, Ericsson et al. 1995, Hermann et al. 2001, King et al. 2002). After 9 months of healing in labrador dogs, Ericsson et al. (1995) observed that the bone crest consistently was located about 1–1.5 mm apical of the abutment-fixture level. The bone crest was commonly separated from the abutment inflammatory cell infiltrate (ICT) by a 1.0 mm wide zone of a normal non-infiltrated connective tissue. Accordingly, the authors concluded that the establishment of an abutment ICT may explain the crestal bone changes during the first year of loading (Ericsson et al. 1995). However, biologic aspects such as the establishment of an adequately dimensioned biological width have also been observed to be associated with crestal bone resorption at sites with a thin mucosa (Berglundh & Lindhe 1996). Similarly, dis- and subsequent re-connections of the abutment component compromised the mucosal barrier and resulted in marginal bone resorption by a more apically positioned zone of connective tissue (Abrahamsson et al. 1997). Moreover, biomechanical aspects such as interfacial shear strengths (Rangert et al. 1989), as well as the influence of the implant design itself (e.g. macro- and microstructure) have also been discussed (Zechner et al. 2004, Shin et al. 2006). In particular, machined titanium implant surfaces located below the bone crest level revealed significantly the highest bone changes (Hermann et al. 2000). In recent years, a horizontal inward re-positioning of the implant–abutment interface, commonly termed platform switching, has been suggested in order to overcome some of the problems. Hypothetically, platform switching may increase the distance between the abutment ICT and the alveolar crest, thus decreasing its bone-resorptive effect. Moreover, with the increased surface area created by the exposed implant seating surface, there might be a reduction in the amount of crestal bone resorption necessary to expose a minimum amount of implant surface to which the soft tissue can attach (Lazzara & Porter 2006). However, for the time being, there are virtually no data from animal studies evaluating platform switching as a technique for preserving crestal bone around endosseous titanium implants. Therefore, the aim of the present study was to investigate histomorphometrically the influence of platform switching on crestal bone changes at non-submerged wide-body titanium implants in a dog model.

Material and Methods

Animals

Nine beagle dogs (age 20–24 months, mean weight 14.2 ± 0.6 kg) were used in the study. All animals exhibited a fully erupted permanent dentition. During the experiment, the dogs were fed once per day with soft-food diet and water. Animal selection, management, and surgery protocol were approved by the Animal Care and Use Committee of the Heinrich Heine University and the Bezirksregierung, Düsseldorf. The experimental segment of the study started after an adaption period of 4 weeks.

Study design

The study was performed in two surgical phases. In the first phase, extraction of the mandibular and maxillary second, third, fourth pre-molar as well as the first and second molar (P2–M2) was performed bilaterally. After 3 months of healing, sand-blasted and acid-etched screw-typed wide-diameter titanium implants with either matching or smaller diameter healing abutments were randomly assigned to the lower jaws according to a split-mouth design, including three implants per group. Three animals each were assigned to healing periods of 7, 14, and 28 days.

Titanium implants and randomization procedure

Commercially available titanium implants (∅5.0 mm, length: 11 mm, Camlog™ Implant, Promote® plus, Camlog, Basel, Switzerland) with matching wide-body healing abutments (∅5.0 mm, height: 4 mm, Camlog) served as control (CAM). An experimental CAM implant (∅5.0 mm, length: 11 mm, internal conus connection) (CPS) was modified in order to allow platform switching. In particular, CPS implants revealed an outer bevelled (45°) part of 0.3 mm, and an inner horizontal part of 0.2 mm. The connection of diameter reduced healing abutments (∅4.0 mm, height: 4 mm, Camlog) resulted in a circumferential horizontal mismatch of 0.5 mm. With the exception of the internal conus connection and the outer bevelled (45°) part of 0.3 mm, both CPS and CAM implants had an identical design, exhibiting a machined-neck size of 0.4 mm (Fig. 1). Implant randomization to allow platform switching was performed according to a computer-generated list (RandList®, DatInf GmbH, Tübingen, Germany). Accordingly, each animal received a total of six implants; three CPS in one side of the mandible and three CAM in the other side.

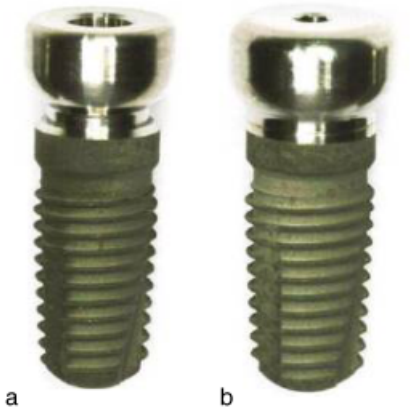


Fig. 1. (a) Platform-switching was created by connecting wide-diameter (∅5.0 mm) test implants with smaller-diameter healing abutments (∅4.0 mm), resulting in a circumferential horizontal mismatch of 0.5 mm. In particular, the circumferential plateau revealed an outer bevelled (45°) part of 0.3 mm, and an inner horizontal part of 0.2 mm. (b) Commercially available wide-diameter implants (∅5.0 mm) with matching wide-body healing abutments served as control. Both types of implants had an identical design, exhibiting a machined-neck size of 0.4 mm.

Surgical procedure

Following intramuscular sedation with 0.17 mg/kg acepromazine (Vetranquil 1%, Ceva Tiergesundheit, Düsseldorf,

Germany), anaesthesia was initiated using 21.5 mg/kg thiopental–sodium (Trapanal 2.5%, Altana GmbH, Konstanz, Germany). During all the surgical procedures, inhalation anaesthesia was performed using oxygen and nitrous oxide and isoflurane. To maintain hydration, all animals received a constant-rate infusion of lactated Ringer's solution while anaesthetized. Intraoperative analgesia was performed by an intravenous injection of 0.4 mg/kg piritramid (Dipidolor®, Janssen-Cilag GmbH, Neuss, Germany), and 4.5 mg/kg carprofene (Rimadyl®, Pfitzer Pharma GmbH, Karlsruhe, Germany). For post-operative treatment, piritramid and carprofene were applied subcutaneously for 3 days at the same dose as described before. Additionally, prophylactic administration of clindamycine (11.0 mg/kg body weight, Clerobe®, Pharmacia Tiergesundheit, Erlangen, Germany) was performed intra- and post-operatively for 3 days.

In the first surgery, P2–M2 were carefully removed bilaterally in both jaws after reflection of mucoperiosteal flaps and tooth separation. After wound closure by means of mattress sutures, the sites were allowed to heal for 3 months.

In the second surgery, midcrestal incisions were made and mucoperiosteal flaps were reflected to expose the respective sites for implant insertion in both jaws. Surgical implant sites were prepared bilaterally in the posterior region of the lower jaws, at a distance of 10 mm apart, using a low-trauma surgical technique under copious irrigation with sterile 0.9 % physiological saline (Becker et al. 2006). Particular care was taken to preserve a residual thickness of the alveolar bone crest of at least 1 mm at both buccal and lingual aspects of each implant site. All implants were inserted according to a low-trauma surgical technique with good primary stability in a way so that the implant shoulder (IS) exceeded the alveolar crest of 0.4 mm (ID), as suggested in the surgical protocol of the manufacturer. The abutments were connected (torque: 15 N cm) immediately following implant placement in both groups (Fig. 2a).

Following irrigation, mucoperiosteal flaps were re-positioned with mattress sutures (Resorba® Nürnberg, Germany), and implants were left to heal in a non-submerged position (Fig. 2b).

Retrieval of specimens

The animals were killed (overdose of sodium pentobarbital 3%) after a healing period of 7, 14, and 28 days ($n = 3$ dogs each), respectively, and the oral tissues were fixed by perfusion with 10% buffered formalin administered through the carotid arteries. The jaws were dissected and blocks containing the experimental specimens were obtained. All specimens were fixed in 10% neutral-buffered formalin solution for 4–7 days.

Histological preparation

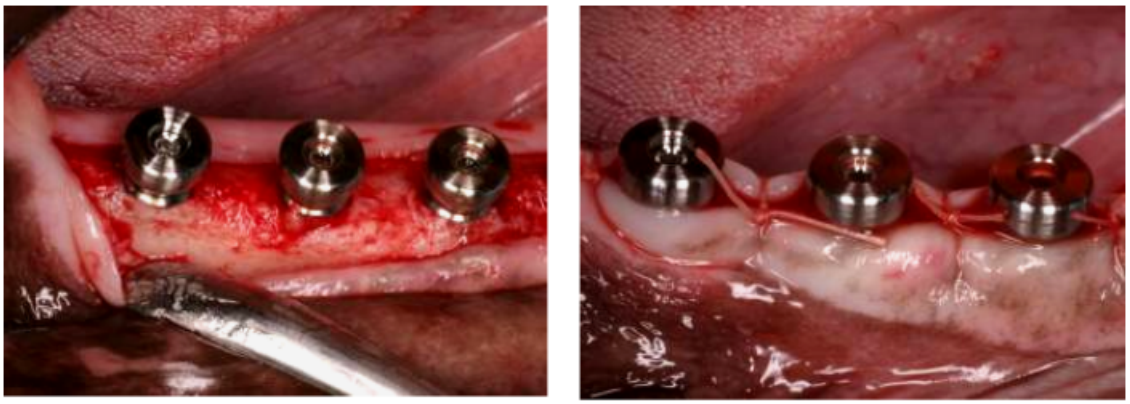
The specimens were dehydrated using ascending grades of alcohol and xylene, infiltrated, and embedded in methylmethacrylate (MMA, Technovit 7200, Heraeus Kulzer, Wehrheim, Germany) for non-decalcified sectioning. After 20 h, the specimens were completely polymerized. Each implant site was cut in the bucco-oral direction along with the long axis of the implant using a diamond wire saw (Exakt®, Apparatebau, Norderstedt, Germany). Serial sections were prepared from the respective specimens, resulting in three sections approximately 500 μm in thickness each (Donath 1985). Subsequently, all specimens were glued with acrylic cement (Technovit 7210 VLC, Heraeus Kulzer) to opaque plexiglas and ground to a final thickness of approximately 30 μm. All sections were stained with Masson Goldner Trichrome.

Histological analysis

Histomorphometrical analyses as well as microscopic observations were performed by one experienced investigator masked to the specific experimental conditions. For image acquisition, a colour CCD camera (Color View III, Olympus, Hamburg, Germany) was mounted on a binocular light microscope (Olympus BX50, Olympus). Digital images (original magnification $\times$ 200) were evaluated using a software program (analySIS FIVE docu®, Soft Imaging System, Münster, Germany).

The following landmarks were identified in the stained sections:

IS, implant shoulder; aJE, the apical extension of the long junctional epithelium; CLB, the most coronal level of bone in contact with the implant; and BC, the level of the alveolar bone crest. Linear measurements were made by



a b

Fig. 2. (a) Both CPS and CAM implants were inserted in such a way that the implant shoulder (IS) exceeded the alveolar crest for 0.4 mm (ID). Accordingly, in both groups, the machined neck was located at the bone crest level. Particular care was taken to preserve a residual thickness of the alveolar bone crest of at least 1 mm at both buccal and lingual aspects of each implant site. (b) The implants were left to heal in a non-submerged position.

drawing a vertical line, following the long axis of the implant, from IS to aJE (IS–aJE), from IS to CLB (IS–CLB), and from IS to BC (IS–BC).

Statistical analysis

The statistical analysis was performed using a commercially available software program (SPSS 15.0, SPSS Inc., Chicago, IL, USA). The mean values and standard deviations among animals were calculated for each variable and group. The data rows were examined with the Kolmogorow–Smirnow test for normal distribution. For the statistical evaluation of the changes within groups (i.e. buccal and lingual aspects, changes over time), the paired *t*-test was used. For the comparisons between groups, the unpaired *t*-test was used. The α error was set at 0.05.

Results

The post-operative healing was considered to be generally uneventful in all dogs. No complications such as allergic reactions, abscesses, or infections were observed throughout the whole study period.

Histological observations/ histomorphometrical analysis

The mean values of IS–aJE, IS–CLB, and IS–BC for each group at 7, 14, and 28 days are presented in Tables 1 and 2. The difference in IS–aJE, IS–CLB, and IS–BC between CAM and CPS implants at respective time points is presented in Table 3.

At 7 days, the down-growth of the junctional epithelium markedly differed between both groups. While aJE tended to stop at the level of the inner horizontal part of the circumferential plateau at CPS implants, the junctional epithelium commonly proliferated along the machined supracrestal titanium surface of CAM implants (Figs 3a and 4a). At the lingual aspect, the difference in IS–aJE between groups reached statistical significance ($p<0.05$; unpaired *t*-test). Masson Goldner staining revealed tiny areas of newly formed trabeculae of woven bone, spanning the gap between the adjacent alveolar bone as well as residual bone particles and the endosseous part of both implants. The difference in IS–CLB and IS–BC between groups at both buccal and lingual aspects was not significant ($p>0.05$, respectively, unpaired *t*-test) (Tables 1–3).

At 14 days following implant placement, the mean IS–aJE values slightly increased in both groups ($p>0.05$, respectively, paired *t*-test). The difference in IS–aJE between groups was significant at both buccal and lingual aspects ($p<0.05$, respectively, unpaired *t*-test). Wound healing within the endosseous part of both CAM and CPS implants was mainly characterized by the ongoing formation and maturation of new bone. In particular, both groups revealed an increased condensation of newly formed trabeculae into the implant threads, covering larger parts of the endosseous surfaces. The maturation of the newly formed bone was also identifiable by the development of primary osteons. Accordingly, the mean IS–CLB values significantly decreased to a level equivalent to IS–BC in both groups ($p<0.05$, respectively, paired *t*-test). The difference in IS–CLB and IS–BC between groups at both buccal and lingual sites was not significant ($p>0.05$, respectively, unpaired *t*-test) (Figs 3b and 4b, Tables 1–3).

Table 1. Mean values (± SD) of IS–aJE, IS–CLB, and IS–BC (in mm ± SD) at CAM implants after 7, 14, and 28 days of healing ($n = 9$ dogs)

Day	Site	IS–aJE	IS–CLB	IS–BC
7	Buccal	0.5 ± 0.3	1.7 ± 0.4	0.6 ± 0.3
	Lingual	0.6 ± 0.2	1.8 ± 0.3	0.6 ± 0.2
14	Buccal	0.7 ± 0.1	0.9 ± 0.3*	0.7 ± 0.4
	Lingual	0.8 ± 0.1	0.8 ± 0.3*	0.5 ± 0.3
28	Buccal	0.9 ± 0.4*	1.9 ± 0.3	1.7 ± 0.3**
	Lingual	1.1 ± 0.6*	1.8 ± 0.6	0.9 ± 0.3

Comparisons within groups (to day 7):
*$p<0.05$.
**$p<0.01$; paired *t*-test, respectively.
aJE, the apical extension of the long junctional epithelium; BC, the level of the alveolar bone crest; CLB, the most coronal level of bone in contact with the implant; IS, implant shoulder.

Table 2. Mean values (± SD) of IS–aJE, IS–CLB, and IS–BC (in mm ± SD) at CPS implants after 7, 14, and 28 days of healing ($n = 9$ dogs)

Day	Site	IS–aJE	IS–CLB	IS–BC
7	Buccal	0.1 ± 0.1	1.6 ± 0.5	0.5 ± 0.1
	Lingual	0.1 ± 0.1	1.6 ± 0.4	0.4 ± 0.2
14	Buccal	0.2 ± 0.1	0.8 ± 0.2*	0.7 ± 0.2
	Lingual	0.2 ± 0.2	0.7 ± 0.1*	0.6 ± 0.2
28	Buccal	0.2 ± 0.1	1.3 ± 0.4	1.2 ± 0.2**
	Lingual	0.1 ± 0.1	1.2 ± 0.5	0.8 ± 0.2

Comparisons within groups (to day 7):
*$p<0.05$.
**$p<0.01$; paired *t*-test, respectively.
aJE, the apical extension of the long junctional epithelium; BC, the level of the alveolar bone crest; CLB, the most coronal level of bone in contact with the implant; IS, implant shoulder.

Table 3. Difference Δ (in mm ± SD) in IS–aJE, IS–CLB, and IS–BC between CAM and CPS implants after 7, 14, and 28 days of healing ($n = 9$ dogs)

Day	Site	Δ IS–aJE	Δ IS–CLB	Δ IS–BC
7	Buccal	0.4 ± 0.3	0.1 ± 0.0	0.1 ± 0.3
	Lingual	0.5 ± 0.1*	0.2 ± 0.2	0.2 ± 0.4
14	Buccal	0.5 ± 0.0*	0.1 ± 0.3	0.0 ± 0.5
	Lingual	0.6 ± 0.1*	0.1 ± 0.4	− 0.1 ± 0.3
28	Buccal	0.7 ± 0.2*	0.6 ± 0.2	0.5 ± 0.5
	Lingual	1.0 ± 0.4*	0.6 ± 0.2	0.1 ± 0.5

Comparisons between groups:
*$p<0.05$; unpaired *t*-test, respectively.
aJE, the apical extension of the long junctional epithelium; BC, the level of the alveolar bone crest; CLB, the most coronal level of bone in contact with the implant; IS, implant shoulder.

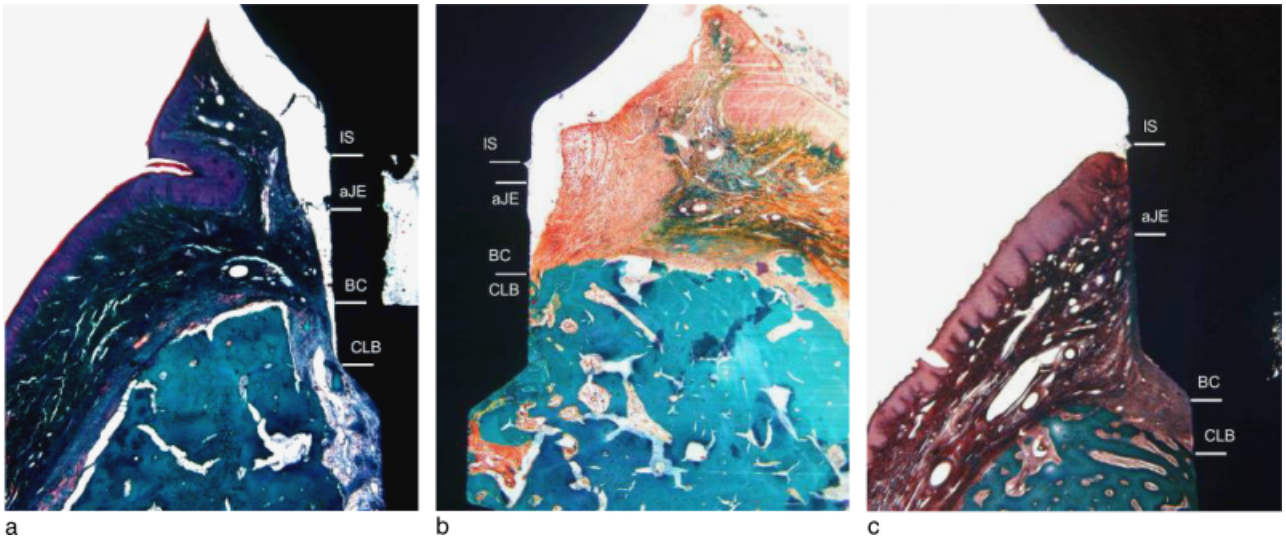


Fig. 3. Representative histological views (Masson Goldner stain) of crestal bone changes at CAM implants (original magnification × 40). The junctional epithelium commonly proliferated along the machined supracrestal titanium surface of CAM implants. (a) 7 days (buccal site), (b) 14 days (lingual site), and (c) 28 days (buccal site). Landmarks for histomorphometrical analysis: IS, implant shoulder; aJE, the apical extension of the long junctional epithelium; CLB, the most coronal level of bone in contact with the implant; BC, the level of the alveolar bone crest.

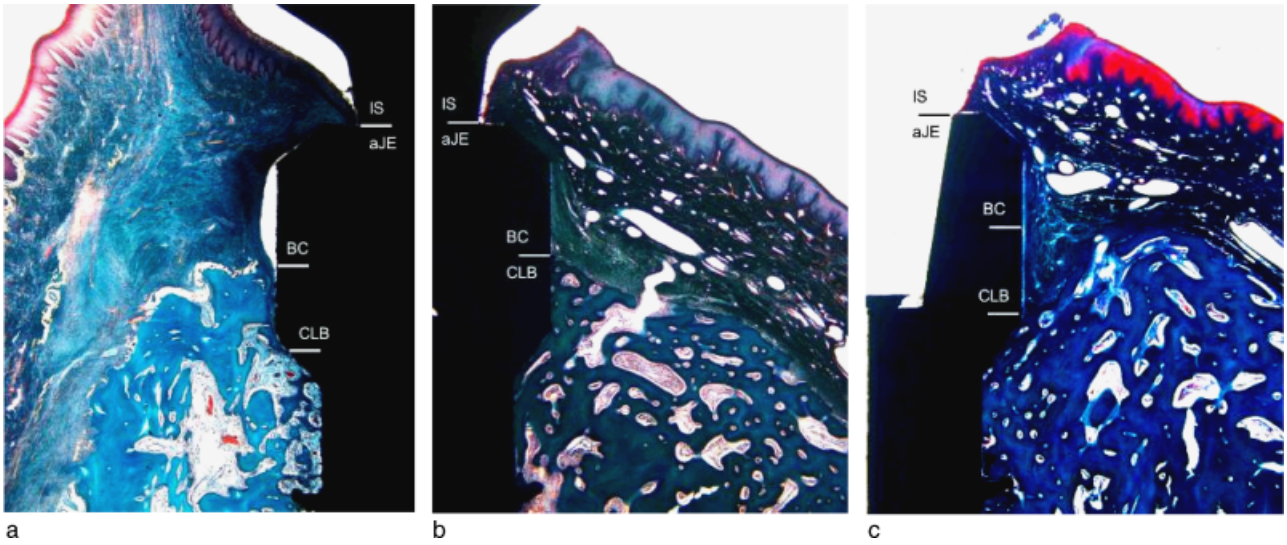


Fig. 4. Representative histological views (Masson Goldner stain) of crestal bone changes at CPS implants (original magnification × 40). The circumferential horizontal mismatch of 0.5 mm was able to prevent the apical down-growth of the barrier epithelium over an observation period of 28 days. (a) 7 days (buccal site), (b) 14 days (lingual site), and (c) 28 days (lingual site). Landmarks for histomorphometrical analysis: IS, implant shoulder; aJE, the apical extension of the long junctional epithelium; CLB, the most coronal level of bone in contact with the implant; BC, the level of the alveolar bone crest.

After 28 days of healing, both CAM and CPS implants revealed a continuous filling of the intertrabecular spaces within the endosseous part and subsequently a transformation into primary and secondary osteons. While CAM implants exhibited significantly increased mean IS–aJE values ($p < 0.05$, respectively, paired *t*-test), these values remained unchanged in the CPS group ($p > 0.05$, respectively, paired *t*-test) (Figs 3c and 4c). The difference in IS–aJE between groups was significant at both buccal and lingual aspects ($p < 0.05$, respectively, unpaired *t*-test). In particular, the apical portion of the junctional epithelium still appeared to be attached to the inner horizontal part of the circumferential plateau at CPS implants (Fig. 4c). In contrast, the apical down-growth of the epithelial cells in the CAM group (Fig. 3c) was associated with increased mean IS–CLB values, even reaching mean values that were observed at day 7 ($p > 0.05$, respectively, paired *t*-test). However, a slight increase in the mean IS–CLB values was also observed in the CPS group ($p > 0.05$, respectively, paired *t*-test). In both groups, the mean IS–BC values increased compared with day 7, even reaching statistical significance at the buccal aspect of the crestal alveolar

bone ($p < 0.01$, respectively, paired *t*-test) (Figs 3c and 4c, Tables 1 and 2). The difference in IS–CLB and IS–BC between groups at both buccal and lingual aspects was not significant ($p > 0.05$, respectively, unpaired *t*-test) (Table 3).

Discussion

The present study was designed to investigate histomorphometrically the influence of platform switching on crestal bone changes at non-submerged wide-body titanium implants in a dog model. Within its limits, it was observed that a circumferential horizontal mismatch of 0.5 mm at CPS implants was able to prevent the apical downgrowth of the barrier epithelium over an observation period of 28 days. In contrast, standard healing abutments at CAM implants resulted in significantly increased mean IS–aJE values of 0.9 ± 0.4 mm at buccal and 1.1 ± 0.6 mm at lingual sites. This was associated with a significant loss of the crestal alveolar bone, particularly at the buccal sites. Even though these values were significantly reduced at CPS implants, platform switching was not able to prevent an increase in the mean IS–CLB and IS–BC values after 28 days of healing. In this context, however, it must be emphasized that IS–CLB values initially describe the pattern of osseointegration, rather than crestal bone level changes at both implants. In particular, the mean IS–CLB values decreased significantly between days 7 and 14 in both groups, indicating that newly formed bone had spanned the gap between the implant surface and the adjacent alveolar bone. However, changes in the mean IS–CLB values between days 14 and 28 might be a result of crestal bone remodelling in both groups. Moreover, when interpreting these results, one must keep in mind that the present study does not have the statistical power to rule out the possibility of a difference between both groups. Therefore, further studies with a higher number of animals and implant sites are needed in order to clarify this issue. In general, the mean IS–aJE values as observed in the CAM group were within the range of the data reported in previous experimental animal studies (Berglundh et al. 1991, 2007, Berglundh & Lindhe 1996, Abrahamsson et al. 1996, 1998, Schwarz et al. 2007). In particular, Berglundh et al. (2007) observed the first signs of epithelial proliferation after 1–2 weeks of non-submerged healing in a dog model. The barrier epithelium revealed an apical proliferation of 0.5 mm at 1–2 weeks and of 1.42 mm at 4 weeks, occupying about 60% of the entire soft tissue that established contact with one-piece implants. However, it was also reported that a mature barrier epithelium as well as an organization of the collagen fibres of the mucosa occurred after 6–8 weeks of healing (Berglundh et al. 2007). Accordingly, it must be emphasized that an observation period of 28 days, as defined in the present study, might not be sufficient to draw any final conclusions on the healing of the mucosa at both CPS and CAM implants. On the other hand, however, most recent histological data revealed similar mean IS–aJE values for the CAM implant after 2 and 12 weeks of healing in beagle dogs. Moreover, the mean IS–CLB and IS–BC values also increased significantly from 1.0 ± 0.3 and 0.6 ± 0.2 mm at 2 weeks, to 1.6 ± 0.03 and 1.6 ± 0.02 mm at 12 weeks, respectively (Schwarz et al. 2007). In this context, however, it must be emphasized that the implants were cut in the mesio-distal direction. Therefore, it might be difficult to compare crestal alveolar bone changes at mesial/distal and buccal/lingual sites. Indeed, previous results from an animal study support the view that remodelling and resorption following implant placement seemed to be most pronounced at the buccal sites of the alveolar bone (Botticelli et al. 2004). When interpreting the present results, it was noted that CPS implants also showed the highest increases of mean IS–BC values at the buccal aspect. As described above, there might be several possible reasons to explain crestal bone changes in both groups. First of all, it must be emphasized that the mobilization of mucoperiosteal flaps might have caused an insult on the periosteum, leading to a certain amount of crestal resorption of the alveolar bone (Pihlström et al. 1983). Second, several studies have reported on microbial leakage, resulting in a mucosal inflammatory reaction that might have influenced marginal bone resorption (Mombelli et al. 1987, Hermann et al. 2001, King et al. 2002). Indeed, the results of a previous in vitro study have shown that CAM implants exhibited bacterial leakage along the implant–abutment interface. In an artificial chewing simulator, the implant systems were investigated with respect to the number of chewing cycles until bacterial penetration was found (Steinebrunner et al. 2005). This observation might also be supported by the results of a recent animal study, indicating a slight ICT in the connective tissue adjacent to the implant–abutment interface of CAM implants. However, after 2 and 12 weeks of healing, the ICT was clearly separated from the implant supporting alveolar bone by a sound subepithelial connective tissue zone (Schwarz et al. 2007). Accordingly, it might be hypothesized that microbial leakage apparently did not contribute to the marginal bone resorption at CAM implants. Because these are the first data investigating platform switching created by connecting wide-diameter CPS implants with smaller-diameter healing abutments, it is impossible to estimate the influence of microbial leakage in this group. However, it might be hypothesized that the inward horizontal re-positioning of the implant–abutment interface away from the crestal bone into a more confined area has positively influenced bone resorption at CPS implants (Lazzara & Porter 2006). Therefore, further investigations are needed in order to clarify this issue. Finally, as described above, biologic aspects such as the establishment of an adequately dimensioned biological width might also have influenced crestal bone resorption (Berglundh & Lindhe 1996). In particular, previous experimental animal studies provide clear evidence that the attachment between the mucosa and the titanium implant surface consists of an epithelial portion of about 1.5–2 mm as well as a zone of connective tissue of about 1–1.5 mm (Berglundh et al. 1991, Abrahamsson et al. 1996, 1998, Berglundh & Lindhe 1996). All these findings taken together with the results from the present study seem to indicate that the concept of platform switching was able to prevent the apical down-growth of the barrier epithelium over an observation period of 28 days. In comparison with matching standard abutments, however, this was also associated with a significant loss of the crestal alveolar bone, particularly at the buccal sites.

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Clinical Relevance

Scientific rationale for the study: A horizontal inward re-positioning of the implant–abutment interface, commonly termed platform switching, might reduce the amount of crestal bone resorption necessary to expose a minimum amount of implant surface to which the soft tissue can attach.

Principal findings: The present results have indicated that a circumferential horizontal mismatch of 0.5 mm was able to prevent the apical down-growth of the barrier epithelium over an observation period of 28 days. In comparison with matching standard abutments, however, this was also associated with a loss of the crestal alveolar bone, particularly at the buccal sites.

Practical implications: The concept of platform switching might have a limited effect on the prevention of post-operative crestal bone changes.