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Ridge alterations following flapless immediate implant placement with or without immediate loading. Part II: a histometric study in the Beagle dog

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Abstract

Objective: To assess the effect of immediate loading on ridge alterations following implants placed into fresh extraction sockets in a dog model.

Material and Methods: Six Beagle dogs were used. Four implants were placed into post-extraction sockets in the lower jaw immediately after the removal of premolars 3 and 4. In the control side, two implants remained without occlusal loading, and in the test side, they received an immediate prosthesis with occlusal contacts (involving implant sites). Extraction sockets without implants were used as a test in non-involved implant sites. Three months later, the dogs were sacrificed.

Results: Vertical distance from implant shoulder to bone crest (BC) was similar for both groups. BC at the buccal aspect was located 3.66 mm apical to the shoulder in the test group and 4.11 mm in the control group. This difference was not statistically significant. Buccal bone resorption was more pronounced in the premolar 3 area than in the premolar 4 area. In edentulous sites, the buccal bone crest was located 0.97 mm apical to the lingual counterpart.

Conclusion: Immediate implant placement with or without immediate loading does not prevent the amount of bone resorption that occurs following tooth extraction without immediate implant placement.

Key words: flapless surgery; immediate implants; immediate loading; ridge alterations

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Several experimental and human studies have shown that alveolar bone dimensions are reduced following tooth extraction (Johnson 1963, 1969, Pietrokovski & Massler 1967, Schropp et al. 2003, Araújo & Lindhe 2005).

Schropp et al. (2003), in a prospective clinical study, showed that about 50% of the bucco-lingual width of the alveolar bone was lost 12 months following single tooth extraction. An important finding was that two-thirds of this loss occurred within the first 3 months.

Paolantonio et al. (2001) suggested that the placement of implants into post-extraction sockets could maintain the original shape of the alveolar ridge. Moreover, the survival rates of implants placed into post-extraction sites are similar to those implants placed in healed sites (Chen & Buser 2009).

However, experimental models have shown that following immediate implant placement, a process of bone resorption

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occurs, mainly on the buccal aspect (Araújo et al. 2005, Araújo et al. 2006a, b, Blanco et al. 2008). The amount of resorption in the pre-clinical models of immediate implants is inconsistent and it may be affected by implant location (Caneva et al. 2010b), implant diameter (Caneva et al. 2010a), implant surface (Vignoletti et al. 2009), socket dimension and thickness of the buccal bone plate (Araújo et al. 2006a, b), and the surgical approach (Blanco et al. 2008, Caneva et al. 2010c).

On the other hand, experimental studies evaluating the hard tissue healing of immediate implants in humans (Botticelli et al. 2004, Sanz et al. 2010) have shown a similar amount of horizontal bone resorption to that observed at sockets that heal spontaneously after tooth extraction (Schropp et al. 2003).

Some authors have suggested that certain loads may increase the amount of mineralized bone at the bone-to-implant interface and in the peri-implant bone area (Wehrbein et al. 1998, Gotfredsen et al. 2001). Immediate implant loading may stimulate bone formation and may thus influence the early stages of osseointegration (Romanos et al. 2002, 2003). Moreover, immediately loaded implants present survival rates similar to implants loaded in a delayed protocol (Esposito et al. 2009).

The combination of immediate implant placement and loading shows survival rates that are slightly lower than those of immediate loading of implants placed in healed sites. However, the bimodal approach showed favourable marginal bone changes after 1 year (Atieh et al. 2009).

A recently published minipig study showed that the amount of bone resorption was similar in immediate implants with immediate loading as immediate implants with delayed loading, in non-splinted implants (Liñares et al. 2011).

The objective of the present investigation was to assess the effect of immediate loading on ridge alterations following implants placed into fresh extraction sockets in a dog model.

Material and Methods

Once approval from the Ethics Committee of the University of Santiago had been given, this research was carried out using six Beagle dogs. They were provided by the School of Veterinary Studies at the University of Cordoba and were installed in the Animal Experimentation Service facility at the Veterinary Teaching Hospital Rof Codina of Lugo. The animals were maintained in individual kennels in a 12:12 light/dark cycle (lights on at 07:00 hours) and $22 \pm 2^{\circ}C$, with regular chow and tap water. All experiments were performed according to the Spanish Government Guide and the European Community Guide for animal care.

Experimental Study

Surgical procedure

The experimental model used in this study was reported recently (Blanco et al. 2010). Six Beagle dogs, about 2 years old and 20 kg in weight, were enrolled in the study. During the surgical procedures, the animals were pre-medicated with acepromacine (0.05 mg/kg intramuscularly) and morphine (0.2 mg/kg intravenously). Immediately after, they were subjected to general anaesthesia by an injection of propofol (2 mg/kg intravenously). Isofluorane (1.5–2%) and O_2 (100%) were used as inhalated anaesthetics.

In total, 24 implants were placed in six dogs. All implants were 8 mm long, 3.3 mm in diameter with a standard neck height (2.8 mm), Straumann Dental Implant System (Institute Straumann, Basel, Switzerland). All the implants had a sand-blasted and acid-etched (SLA) surface. The implants were placed into fresh extraction sockets and bone augmentation procedures were not attempted.

The lower premolars 3 and 4 were carefully removed, separating the roots by means of tooth hemisectioning using a fissure bur and extracting them individually with elevators and forceps (Fig. 1a and b). After the extraction, immediate implants were placed into the centre of the distal socket of each tooth (Fig. 1d–g). Four implants were placed in each dog (two in each hemimandible) according to the manufacturer's protocol (Straumann® Dental Implant System, Basel, Switzerland). The implants were placed so that the marginal level of the SLA-coated surface was flush with the buccal bone crest. In order to achieve this, the buccal soft tissue height was measured using a periodontal probe immediately before implant installation and keeping in mind that the smooth surface of the implant had a height of 2.8 mm (Fig. 1c). Before implant placement, the socket diameter was measured using a periodontal probe. The mean bucco-lingual width was 3.5 ± 0.3 and 3.9 ± 0.3 mm for the premolars 3 and 4, respectively. Thus, after implant placement, a small gap <1 mm was present between the inner part of the socket and the implant surface. No grafting procedures or suturing were performed.

After implant installation, the experimental groups were randomly selected. Two implants of one side (test group) received an immediate loading restoration by means of provisional abutments for bridges (Straumann® Dental Implant System). The provisional prosthesis splinted the implants by an acrylic stent that remained with occlusal contacts with the antagonist teeth. The occlusion was checked again at sacrifice. Short healing caps (1.5 mm height) were connected to the implants in the contra-lateral side (control group) aiming at a non-submerged healing approach without loading (Fig. 1h and i).

The mesial sockets of premolars 3 and 4 were left to heal without implant placement and served as a test in non-involved implant sites. The second mandibular premolars in both the quadrants were not involved in the surgical procedures and were used as controls in the non-involved implant sites.

During the first week after surgery, the animals received amoxicillin (500 mg, twice daily) orally and meloxicam (0.1 mg/kg, once a day) orally. Throughout the experiment, the animals were fed a pellet diet. They were placed on a plaque control regimen that included tooth and implant cleaning three times per week using a toothbrush and dentifrice.

After 3 months of healing, the animals were euthanized with an overdose of sodium pentobarbital through the cephalic veins and a histometric analysis was performed to evaluate the main variables in each group.

Histological preparation

The mandibles were removed and block biopsies of each implant were dissected using an oscillating saw (Donath 1993). The samples were fixed for 1 week in 10% formol. Next, the samples were dehydrated in different graded ethanol series (70–100%) and infiltrated with four different graded mixtures of ethanol and infiltrating resine, glicometacri-

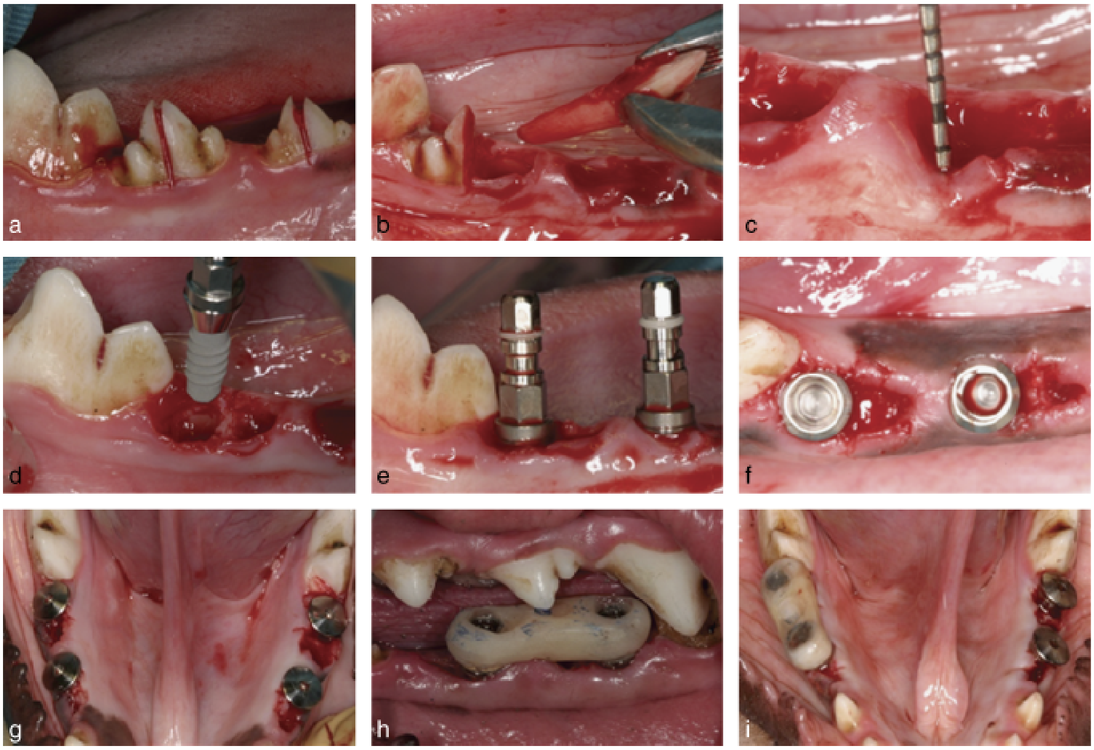

Fig. 1. Clinical photographs illustrating the experimental surgery. (a) Hemisectioning premolars 3 and 4. (b) Tooth extraction. (c) Buccal bone sounding to locate the top of the buccal alveolar crest. (d–g) Flapless immediate implant placement in distal sockets. (h) Immediate loading with a resin provisional screw-retained bridge in the test group. (i) Photograph illustrating the experimental groups.

late (Technovit 7200®, VLC – Heraus Kulzer GMBH, Werheim, Germany), with 1% of benzoyle peroxide (BPO®, Heraus Kulzer GMBH). The last infiltration was performed with pure infiltrating resine under vacuum. The samples were then polymerized, first under low-intensity UV light for 4 h, followed by a polymerization under high-intensity UV light for 12 h and finally by keeping the samples heated for 24 h to ensure complete polymerization.

The samples were glued to a sample holder. Longitudinal sections in the bucco-lingual direction of 200 μm were cut with a band saw and mechanically polished (Exakt Apparatebau, Norderstedt, Germany) using 1200 and 4000 grit silicon carbide papers (Struers, Copenhagen, Denmark) until a samples thickness of 70 μm was obtained and all sections were stained with Levai–Laczko tintion for histometric analysis.

Histometric analysis

The samples on the permanent ports were observed using the Olympus® SZX9 microscope (Olympus, Tokyo, Japan). By means of the Olympus® DP12 digital camera (Olyumpus), the images were captured and transferred to the computer. With the Microimage® program, the points of interest were identified from the digital histological images in order to measure the distances, which were expressed in millimetres.

Implant site

A line was traced along the digital image parallel to the implants' longitudinal axis. The following marks were then marked on both the vestibular and the lingual side of each implant (Fig. 2a):

- S: implant shoulder.
- PM: peri-implant mucosa margin.
- IC: most coronal contact point of the bone with the implant.
- BC: bone crest.

From each point, a perpendicular line was traced towards a parallel line along the implants longitudinal axis and the following measures (expressed in millimetres) were taken:

- S–BC: distance from the implant shoulder to the bone crest.
- S–IC: distance from the implant shoulder to the most coronal bone implant contact.
- BCb–BCl: vertical distance between the buccal and the lingual bone crest.

Tooth site

At tooth sites (premolar 2), the following marks were identified at the buccal and lingual side (Fig. 2b):

- CEJ: cemento-enamel junction.
- BC: bone crest (buccal/lingual).
- GM: gingival margin.

From each point, a perpendicular line was traced towards a parallel line along the tooth longitudinal axis and the following measurements (expressed in millimetres) were taken:

- GM–BC: distance from the gingival margin to the bone crest.
- GM–CEJ: distance from the gingival margin to the cemento-enamel junction.
- CEJ–BC: distance from the cemento-enamel junction to the bone crest.

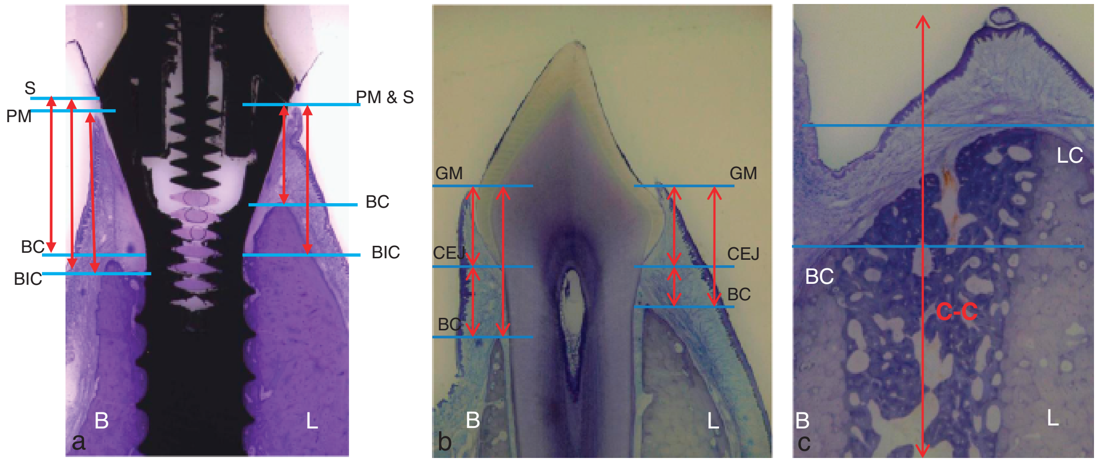

Fig. 2. Landmarks used for histometric measurements. (a) Implant site; PM, peri-implant mucosa margin; S, implant shoulder; BC, marginal bone crest; IC, most coronal bone to implant contact. (b) Tooth site; GM, gingival margin; CEJ, cement–enamel junction; BC, bone crest. (c) Edentulous site; BC, buccal crest; LC, lingual crest. Levai–Laczko staining method. Original magnification $\times$ 1.6.

Edentulous site

At the edentulous sites, the height of the cortical bone walls was determined in the following way according to Araújo & Lindhe (2005) (Fig. 2c): a line parallel to the long axis of the centre of the socket was drawn (C–C) to separate the buccal and lingual compartments. Subsequently, horizontal lines (LC and BC) perpendicular to C–C were drawn to connect the most coronal portions of the buccal and lingual bone crest to C–C. The vertical distance between the buccal and the lingual intersections with C–C was measured and expressed in mm (LC–BC).

Statistical analysis

The statistical analysis was performed using the Sigma-Stat® statistics program.

Descriptive statistics were taken for each of the variables and groups (mean values and standard deviation).

To compare the implant groups in each variable for test and control and implant position (premolar 3 or 4), Student's *t*-test for paired observations was used.

The dog was used as a unit for analysis ($n = 6$), using average results across similarly treated implants in the same dog and then compared. p-Values <0.05 were considered statistically significant.

Results

Clinical observations

In total, 24 implants were immediately placed following tooth extraction; 12 of them were immediately loaded and the other 12 remained without loading in a non-submerged healing approach. At the end of the experimental period, none of the implants and prosthesis was lost. At the time of sacrifice, all restorations were still in service and the occlusal contacts remained in the provisional bridge; however, all restorations showed abrasion of the occlusal aspects.

Histological observations

Implant sites

The histological study showed that the buccal and lingual mucosa in each implant of both groups was covered by a keratinized oral epithelium that continued from the peri-implant marginal mucosa with the barrier epithelium facing the implants. Apical to this epithelium was an area of fibre-rich connective tissue, with fibres oriented parallel to the implant surface.

Tooth sites

The GM was located coronal to the CEJ at the buccal and lingual aspect of each tooth. The bone wall was markedly wider at the lingual than at the buccal aspect of the teeth. The buccal BC was located at a longer distance from the CEJ than the corresponding lingual BC.

Edentulous sites

The mucosa covering the healed socket was lined by an oral epithelium that harboured a well-keratinized surface layer. The underlying, connective tissue was characterized by its densely packed collagen fibres and the lack of infiltrates of inflammatory cells. A newly formed hard-tissue bridge covered the entrance of the extraction socket. This marginal ridge was mainly made up of woven bone, although small areas of lamellar bone could also be observed. The newly formed hard-tissue bridge extended a varying distance into the extraction socket. Apical of the bridge, the edentulous region was comprised of cancellous bone dominated by its bone marrow. The marginal termination of the original buccal bone wall was located apical of its lingual counterpart.

Histometric Results

Implant sites (Table 1 and Figs 3 and 4)

Distance between S and BC

No significant differences were found between groups. Considering that the implant neck is 2.8 mm long, the bone crest at the buccal aspect was roughly 0.86 mm apical to the SLA border and 0.50 mm coronal at the lingual one in the test group. In the control group, the bone crest was located 1.3 mm apical to the SLA border at the buccal and at the same level as the SLA border on the lingual aspect.

Distance between S and IC

No significant differences were found between groups. The most coronal bone-to-implant contact was located

Table 1. Results of histometric measurements in mm (mean and SD) describing the distance between landmarks in the implant sites

	S–IC		S–BC		BC–LC
	Buccal	Lingual	Buccal	Lingual	
Immediate loading ($N=6$)	4.07 ± 0.67	3.10 ± 0.29	3.66 ± 0.44	2.28 ± 0.55	1.38 ± 0.51
No loading ($N=6$)	4.50 ± 0.78	3.17 ± 0.33	4.11 ± 1.04	2.77 ± 0.72	1.34 ± 0.87
p-Value	NS	NS	NS	NS	NS

S–IC, distance from the implant shoulder to first bone-to-implant contact; S–BC, distance from the implant shoulder to the bone crest; BC–LC, vertical distance between buccal and lingual bone crest.

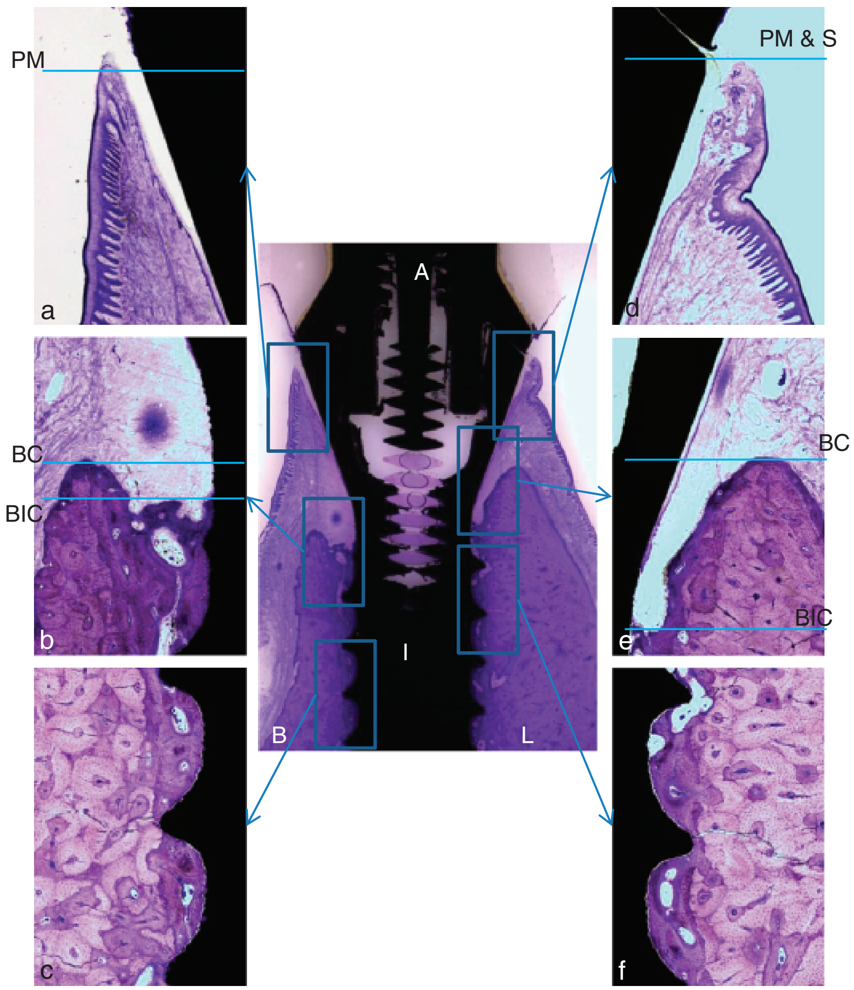

Fig. 3. Buccal–lingual section representing one test implant site after 3 months of healing and loading. B, buccal aspect; L, lingual aspect; I, implant; A, abutment. (a) Note the location of the margin of the PM, peri-implant mucosa apical to the implant shoulder, S. (b) Note that the presence of an intra-bony defect due to the bone crest (BC) is coronal to first bone-to-implant contact (IC). (c) Osseointegration at the mid part of the implant in the buccal aspect. (d) Location of the margin of the PM, peri-implant mucosa at the same level of the implant shoulder. (e) Presence of a larger intra-bony defect as compared with the buccal due to the bone crest (BC) is coronal to first bone-to-implant contact (IC). (f) Osseointegration at the mid part of the implant in the lingual aspect. Levai–Laczko staining method. Original magnification × 1.6 and insets × 16.

1.27 mm apical to the SLA surface and 0.30 mm at the lingual aspect. Again, these distances were similar in the unloaded group: 1.70 mm at the buccal and 0.37 mm at the lingual aspect.

Vertical distance between buccal and lingual bone plate at implant sites

The mean vertical distance between buccal and lingual bone crest was similar in both groups. The difference was not statistically significant. The buccal bone crest was always located apical to the lingual counterpart.

Distance from the implant shoulder (S) to the most coronal bone-to-implant contact (S–IC) and to the bone crest (S–BC) comparing implants from the premolar 3 region with implants from the premolar4 region (Table 2 and Fig. 5)

The mean S–IC (buccal) distance in all implants of the premolar 3 region was 4.67 ± 0.83 and 3.87 ± 0.34 mm in the premolar 4. This difference was statistically significant ($p=0.026$). In the lingual aspect, the difference was not significant. The mean S–BC (buccal) distance in the premolar 3 region was 4.4 ± 0.82 and 3.33 ± 0.33 mm in the premolar 4. This difference was statistically significant ($p=0.004$). Again, there was no difference between premolars 3 and 4 in the lingual aspect.

Tooth sites (Table 3)

The mean distance between the GM and the BC was 3.02 ± 0.38 (buccal) and 2.57 ± 0.34 mm (lingual), while the corresponding distance between GM and CEJ was 2.24 ± 0.34 (buccal) and 1.98 ± 0.39 mm (lingual). The BC was located on average 0.77 ± 0.19 (buccal) and 0.53 ± 0.07 mm (lingual) apical to the CEJ.

Edentulous sites

The mean vertical distance between the buccal and the lingual bone crest was 0.97 ± 0.63 mm. The buccal bone crest always remained apical to the lingual counterpart.

Discussion

The present investigation was designed to assess the impact of immediate implant placement and loading in terms of ridge alterations in the Beagle dog model. This experimental model confirms the results shown in similar animal models of immediate implant placement (Araújo et al. 2005, 2006a, Blanco et al. 2008, Vignoletti et al. 2009, Caneva

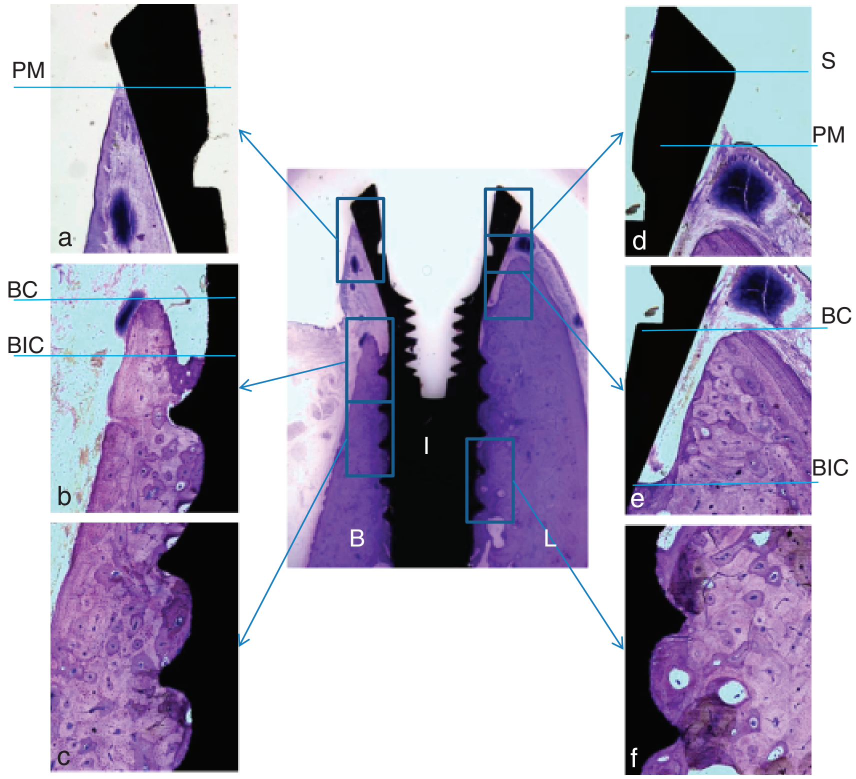

Fig. 4. Buccal–lingual section representing one control implant site after 3 months of healing without loading. B, buccal aspect; L, lingual aspect; I, implant. Note that the level of the buccal bone crest is far apical in comparison with the lingual plate. (a and d) Note the location of the margin of the PM, peri-implant mucosa apical to the implant shoulder, S. (b) Note the apical termination of the barrier epithelium, aBE, and well-keratinized oral mucosa. (c) Bone crest (BC) is coronal to first bone-to-implant contact (IC) forming an intra-bony defect that is more pronounced in lingual (e). (f) Excellent level of bone-to-implant contact. Levai–Laczko staining method. Original magnification × 1.6 and insets × 16.

Table 2. Results of histometric measurements in mm (mean and SD) describing the distance between landmarks in the premolar 3 and premolar 4 regions comparing all implants

	S–IC		S–BC	
	Buccal	Lingual	Buccal	Lingual
Premolar 3 ($N = 6$)	4.67 ± 0.83	3.18 ± 0.34	4.4 ± 0.82	2.67 ± 0.76
Premolar 4 ($N = 6$)	3.87 ± 0.34	3.08 ± 0.26	3.33 ± 0.33	2.33 ± 0.53
p-Value	0.026	NS	0.004	NS

S–IC, distance from the implant shoulder to first bone-to-implant contact; S–BC, distance from the implant shoulder to the bone crest.

et al. 2010a, b, Liñares et al. 2011). This means that a process of bone resorption occurs after tooth extraction, even when an implant is placed immediately in a post-extraction socket. The present study has also evaluated the potential effect of immediate loading in immediate implant placement. No differences were found between the immediate loading group and the unloaded group. These means that the immediate loading protocol did not affect the process of ridge alterations of implants placed immediately after tooth extraction, and this is in agreement with a recently published minipig study (Liñares et al. 2011). The amount of buccal bone resorption showed in that study (0.7 mm test and 0.8 mm control) is similar to the results of the present investigation (0.8 mm test and 1.3 mm control). Several pre-clinical investigations have shown higher amounts of buccal bone resorption. Araújo et al. (2005), in a similar model but without loading, showed 2.6 mm of buccal bone resorption after 3 months of healing of immediately placed implants. In another study, the same group showed, at 2 months of healing, 2.1 mm of buccal bone resorption (Araújo et al. 2006a). This difference could be related to the fact of raising a flap in those studies, but probably more to the implant size, since a 4.1 mm implant was used in those studies in contrast to a 3.3 mm implant used in the present investigation. In fact, a recently published study in the Labrador dog showed almost double bone resorption with a 5 mm implant compared with a 3.3 mm implant (Caneva et al. 2010a). In the present study, the resorption process was more pronounced at the buccal aspect and in the premolar 3 area. The mean distance from the SLA border to the bone crest at the buccal aspect in the premolar 3 area was three times longer than that in the premolar 4 region. The bone crest in premolar 3 was located 1.6 mm apical to the coronal level of the rough surface, and in the premolar 4 area, the bone crest was situated 0.5 mm apical to the same landmark. This is in agreement with the results of a similar study by Vignoletti et al. (2009), who showed that with a 3.25 mm diameter implant the amount of buccal bone resorption was significantly higher in the premolar 3 area in comparison with the premolar 4 area. Moreover, Araújo et al. (2006b), in a similar model but using two different socket sizes, found more bone resorption in the socket of reduced diameter in comparison with the larger one. In the premolar area, the mean distance from shoulder to first bone-to-implant contact was 2 mm; however, in the molar area, it was 0.8 mm. This may be due not only to the size of the socket but also the thickness of the buccal bone plate. The authors stated that the thinner a bone wall, and the closer the implant is placed to this wall, the higher the risk of compromised healing and the occurrence of bone dehiscence. However, it should be considered that the presence of an adjacent tooth to an implant may counteract the bone resorption process following tooth extraction. The implant in the premolar 4 area had an adjacent tooth (molar 1), but the implant in the premolar 3 area did not. Therefore, this situation could have an impact on the final results.

Thus, from this study and previous animal models, it seems that the size of the socket, thickness of the buccal bone plate and implant diameter may play an

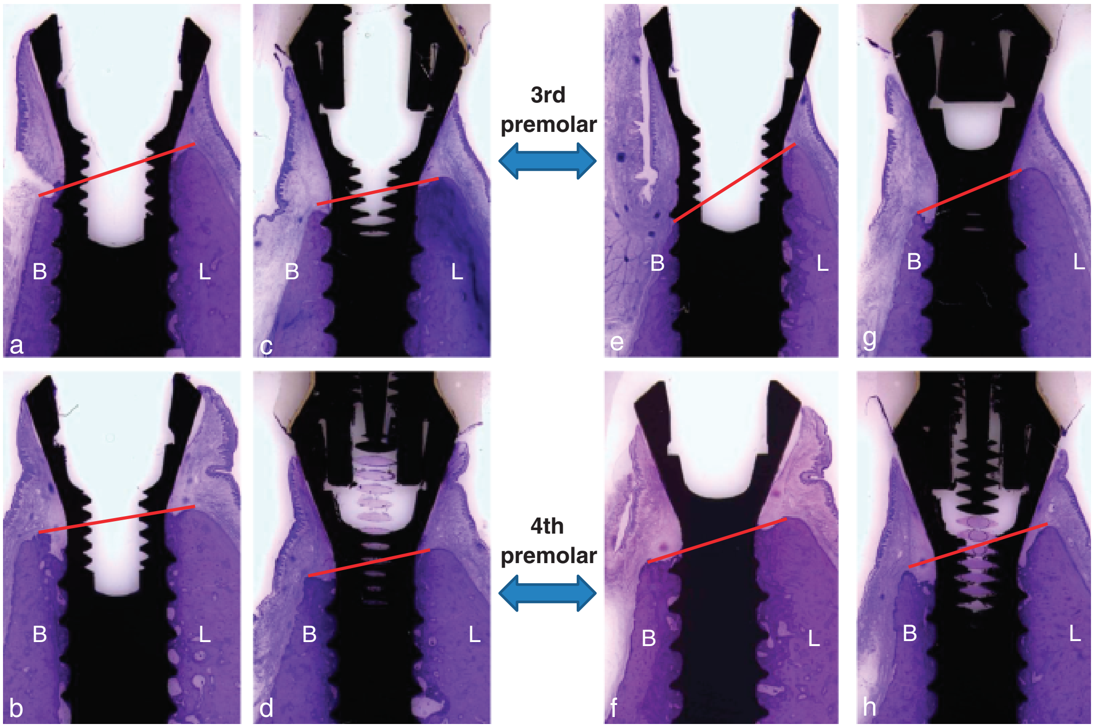

Fig. 5. Buccal–lingual section representing specimens of implant groups at premolar 3 and 4 regions after 3 months of healing. (a–d) Four implants of one animal. (a) Control implant in the premolar 3 region. (b) Control implant of the premolar 4 region. Note the difference in bucccal bone resorption comparing (a) and (b). (c) Test implant of the premolar 3 region and (d) test implant of the premolar 4 region. Again, the amount of bone loss of the buccal bone plate is more pronounced in the premolar 3 implant than in the 4 area. (e–h) Four implants of another animal. (e) Control implant in premolar 3. (f) Control implant in premolar 4. (g) Test implant in premolar 3. (h) Test implant in premolar 4. Note that the amount of bone loss is more pronounced in the buccal aspect and in the premolar 3. Levai–Laczko staining method. Original magnification $\times$ 1.6.

Table 3. Results of histometric measurements in mm (mean and SD) describing the distance between landmarks in tooth sites

GM–CEJ		CEJ–BC		GM–BC	
Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
2.24 ± 0.34	1.98 ± 0.39	0.77 ± 0.19	0.53 ± 0.07	3.02 ± 0.38	2.57 ± 0.34

GM–CEJ, distance from the gingival margin to the cemento–enamel junction; CEJ–BC, distance from the cemento–enamel junction to the bone crest; GM–BC, distance from the gingival margin to the bone crest.

important role in terms of buccal bone resoption after immediate implant placement.

A small intra-bony defect was detected in most of the implants at the end of the experiment, as the distance from implant shoulder to bone crest was shorter than the distance from shoulder to the first bone-to-implant contact. It is unclear whether, after longer healing periods, these defects tend to disappear after a process of bone remodelling.

On the other hand, the present investigation found that the mean vertical distance between the buccal and the lingual bone crest was 0.97 mm at edentulous sites. At implant sites, this distance was longer: 1.38 mm in the test group and 1.34 mm in the control. Thus, almost 0.5 mm more buccal bone resorption was found in the implant sites than in the edentulous sites. Araújo et al. (2005) showed in a similar study the amount of bone resorption following extraction of premolars 3 and 4 with or without immediate implant placement. After 3 months of healing, the amount of buccal bone height reduction (in comparison with lingual bone alteration) was similar at implant sites and edentulous sites. The vertical distance between the buccal and the lingual bone crest was 2.2 mm in edentulous sites and 2.4 mm in implant sites. Thus, the amount of buccal bone resorption in the edentulous sites shown by Araújo was more than double that observed in the present investigation. This could be explained by the surgical approach performed in the Araújo study (raising a flap) in comparison with this study (flapless approach). It must be emphasized that this surgical trauma (flap elevation), implying the separation of the periosteum and its disconnection from the underlying bone surface, will cause vascular damage and an acute inflammatory response, which in turn will mediate the resorption of the exposed bone surface (Wilderman 1963, Staffileno et al. 1966, Wood et al. 1972). Recently, two experimental studies in the Beagle dog have evaluated the impact of elevating a flap for tooth extraction on the dimensional alterations of the ridge. Fickl et al. (2008) compared alveolar bone healing following tooth extraction with or without flap elevation. Plaster casts were taken before, 2 and 4 months after the extractions. Volumetric bone changes were analysed using specially designed software. The results showed an increase of 0.7 mm of volumetric shrinkage of both hard and soft tissues in the flap with respect to the flapless group. Later, Araújo & Lindhe (2009), in a similar experimental model but with a longer follow-up (6 months), showed that the resorption of the alveolar crest was not influenced by the technique for tooth extraction (flap or flapless). Recently, an experimental study in the Labrador dog (Caneva et al. 2010c) showed no difference in terms of bone resorption for post-extraction implants with a flapless or a flap approach. Thus, it seems that in shorter healing periods, the impact of flap elevation may have an effect on early bone resorption, but in longer healing periods, the amount of resorption may be equal when performing tooth extraction with or without flap elevation.

The use of a bone graft, filling the buccal void that may result after implant installation into fresh extraction sockets, could prevent bone resorption; however, conflicting data exist on this issue (Araújo et al. 2011, Hsu et al. in press).

In summary, it can be concluded from the results of the present study that the placement of immediately loaded implants into fresh extraction sockets does not prevent bone resorption that mainly occurs at the buccal bone plate in the normal remodelling process.

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Clinical Relevance

Scientific rationale for the study: There is an increasing interest in immediate implant placement and immediate loading protocols. From a biological point of view, ridge alterations and alveolar bone resorption must be clarified before recommending this technique in daily practice. The present study shows the results in terms of ridge alterations following flapless immediate implant placement with or without immediate loading.

Principal findings: In this animal model, ridge alterations always occurred irrespective of the loading protocol applied to the immediately placed implants.

Practical implications: Buccal bone resorption always occurred and this may compromise the aesthetic outcome of post-extraction implant placement in the anterior area.