# The Role of Incision Design and Location in the Healing Processes of Alveolar Ridges and Implant Host Sites

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This research examined the nature and role of a linea alba, found consistently at the crest of edentulous ridges in dogs. Angiovist dye was used to outline the microvasculature in these regions. The findings demonstrated a zone of avascularity directly beneath each linea alba. When novel incision designs were used in the gingivae and the outlined mucoperiosteal flaps were elevated and then replaced, alterations in underlying bone morphology were noted. In a subsequent study during which implants were placed, a direct relationship was noted between incision design and level of pericervical bone support.
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**Key words:** alveolar bone, implant, incision, linea alba, vascularity

Episodic reports, clinical observations, and a preliminary study have offered evidence of little or no gingival vascular anastomoses at the crest of the edentulous alveolar ridge.[1] This finding is supported clinically by the presence of a midridge, thin, scarred linea alba. When an incision is made directly into this blanched, dense tissue, often no or only slight bleeding is produced. Avascularity in this linear zone may be responsible for retarded healing after dentoalveolar surgery if the visor or another novel incision is used. The experiences of a group of implant practitioners who used either the visor incision or a serpentine ("S"-shaped) incision indicated inconsistent healing, delayed coaptation of flaps, and often, a need for secondary epithelialization. The potential for deleterious effects to underlying bone after an episode of poor soft tissue healing is legitimate. Clarification of these issues was explored in a series of experiments on mongrel dogs.

## Materials and Methods

Nine mongrel dogs, each weighing over 30 kg to guarantee that mandibular widths would be sufficient to accommodate endosseous root-form implants, were acquired. Surgical instruments as well as the requisite armamentaria for anesthetizing the animals and maintaining their airways were available. Angiovist, an aqueous vascular dye, was used at sacrifice.

After clearance by the veterinarian, the dogs were quarantined and anesthetized using intravenous Nembutal, 2.5 mg/kg body weight (Abbott Laboratories, North Chicago, IL). Endotracheal tubes were placed and veins were kept patent by maintaining a "keep vein open" regimen (10 mL/hour). Lidocaine 2%, epinephrine 1:100,000 was used at the operative sites for hemostasis and to minimize the need for additional barbiturates.

The premolar teeth in all quadrants were sectioned through their root bifurcations, split, and removed. Primary closure was achieved using 3-0 black silk sutures. Sutures were removed on the fifth postoperative day, and the dogs were fed a regular diet of Purina Dog Chow after the 10th day. Twelve weeks

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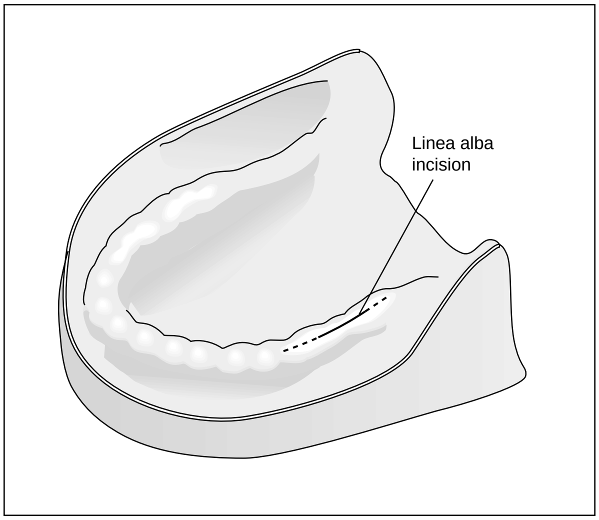


**Fig 1a** A crestal incision (solid line) is made in the linea alba (dotted line), directly on the ridge crest.

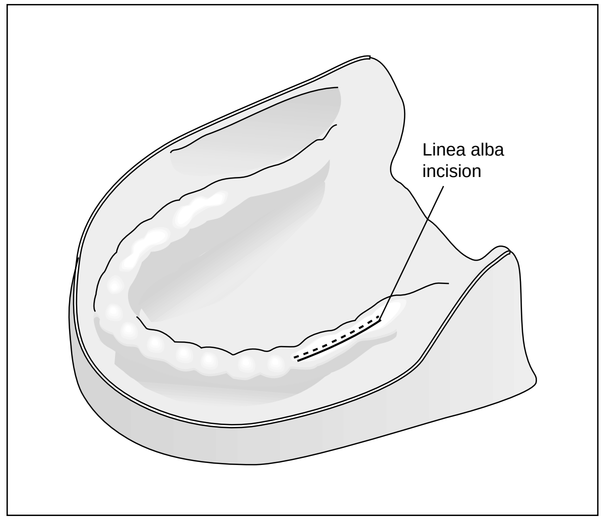


**Fig 1b** A paracrestal incision is made 1.5 mm lateral to the crest and parallel to it.

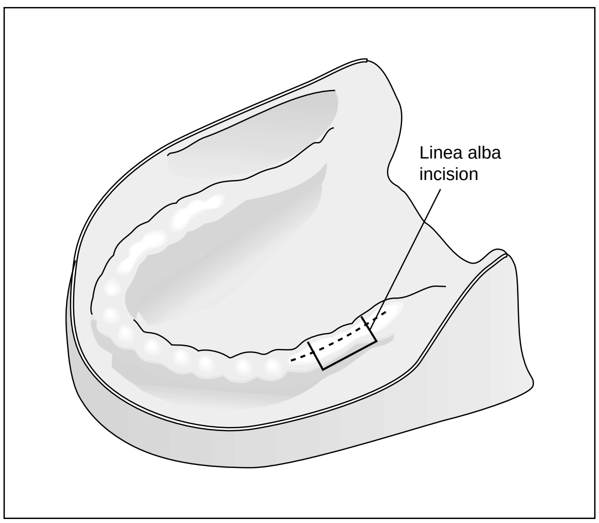


**Fig 1c** A visor incision is made with its base at the ridge crest and its farthest extension parallel to the crest at the vestibular junction.

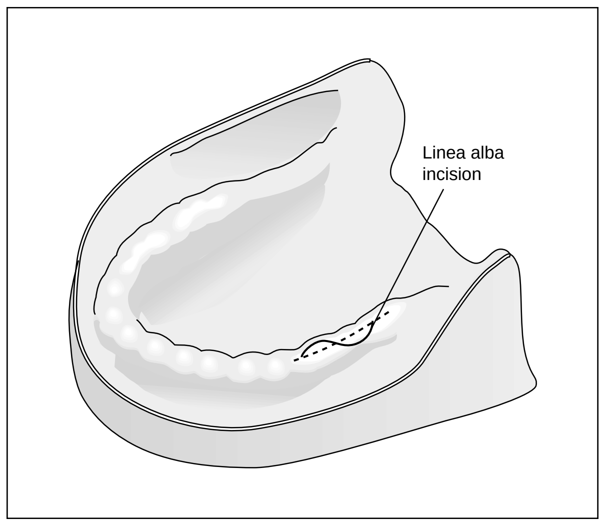


**Fig 1d** A serpentine incision begins at the crest and curves to the buccal vestibule, up and across the ridge to the lingual, and then terminates at the crest.

were allowed to elapse to assure bone healing and the maturation of gingival vascularity. At this juncture, one animal was sacrificed to serve as a control.

The remaining eight experimental dogs were divided into two groups of four. Group A was to have incisions, reflections and closure; group B was to undergo an identical regimen in addition to placement of endosseous implants. The incisions and mucoperiosteal reflections were one of four designs: crestal (C), paracrestal (P), visor (V), and serpentine (S) (Figs 1a to 1d). All four incisions were made in varying quadrants in each of the animals, as noted in Table 1.

Each incision was made of a length sufficient to expose 4 cm of alveolar bone and was limited to a zone of fixed gingivae. In group B, after elevation and reflection of the tissues covering the mandibular alveolar crest, two LifeCore Sustain hydroxyapatite-coated, press-fit implants (LifeCorp, Minneapolis, MN) were placed, each slightly below the cortex (Fig 2), and two Luhr Howmedica fracture screws (Luhr Howmedica Pfizer/Leibinger, Rutherford, NJ) were tapped level with the crest in each maxillary quadrant (Fig 3). These screws were chosen because the dimensions of the maxillae did not permit the use of

**Table 1** Incision Design* and Distribution

| Group | | Maxillary right | Maxillary left | Mandibular right | Mandibular left |
|---|---|---|---|---|---|
| A | B | | | | |
| 1 | 5 | C | P | V | S |
| 2 | 6 | P | V | S | C |
| 3 | 7 | V | S | C | P |
| 4 | 8 | S | C | P | V |

*C = crestal; P = paracrestal; V = visor; S = serpentine.

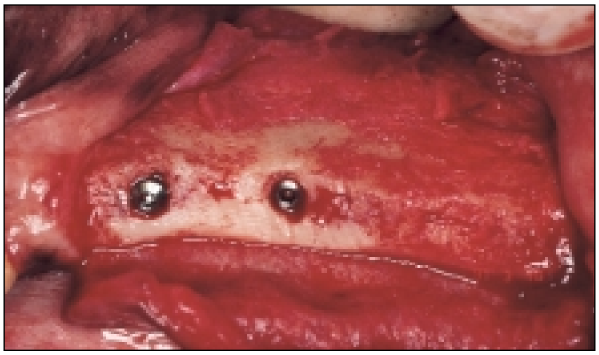

**Fig 2** Two Sustain implants are placed below the ridge crests in each mandibular quadrant prior to closure (van Gieson's stain; magnification ×8).

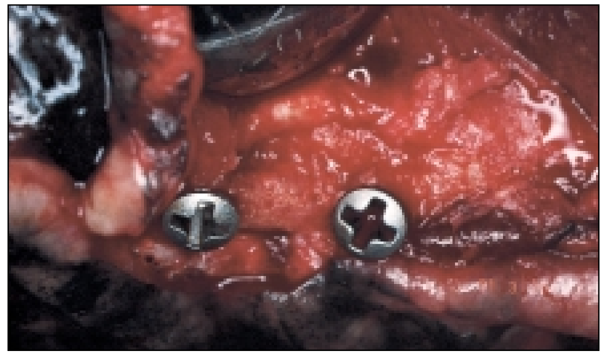

**Fig 3** Two 6 mm Luhr self-tapping screws are placed in each of the maxillary quadrants (van Gieson's stain; ×8).

conventional implants. Closure was completed using interrupted black silk sutures. After recovery of each animal had been assured, 600,000 units of procaine penicillin was given intramuscularly. The animals were then returned to their cages and permitted only pureed food for the first 10 days and a regular diet for the remainder of the experiment.

For group A, clinical observations were made daily, and sutures were removed on the fifth postoperative day. The appearance of the wounds was evaluated by two second-year dental residents, neither of whom was involved in the study. Each rated the status of healing on the fifth day, prior to and after suture removal, and again on the tenth day. Ratings from 0 to 5 were given, with the higher numbers indicating a better status. The residents had been rehearsed in their judgmental capabilities using a Muhlemann color scale for levels of inflammation, a set of standardized photographs of healing canine wound sites culled from a large in-house collection, and repeated clinical evaluations of postoperative wound healing in humans. A rating of five satisfied the criteria of the lightest shade on the color scale: firm, primary wound closure, minimal edema, and correct anatomic apposition of the margins. A rating of 0 indicated the deepest shade of inflammation characterized by wound dehiscence, exposed bone or implant, and the presence of bleeding or transudate. The two residents performing the evaluations gave identical scores on those they rated as 5, 4, or 0. At the intermediate levels, differences were never separated by more than a single number, with only one exception; final ratings were reached by averaging the two scores. The dogs in group A were sacrificed on day 11.

In group B, all dogs were examined daily until all defects and flaws in healing had stabilized, and then weekly evaluations and radiographs were completed. For the radiographs, Kodak ultra-speed D safety film (Eastman Kodak, Rochester, NY) was fitted into a custom-made acrylic resin bite-block filmholder adapted for the Rinn XTP system (Dentsply, Elgin, IL). After they had been marked for identification, the filmholders were stored for use at subsequent examinations. The radiographs taken at each site were virtually superimposable, which gave the examiners reasonable assurance of standardization for the recording of measurements. Actual defect measurements made from the films could be extrapolated mathematically, since the length of each implant was known. The group B animals were sacrificed at the 12th week postimplantation.

The euthanasia technique for both groups involved administration of pentobarbital sodium and dissection and cannulation of the external jugular

**Table 2** Group B Clinical Ratings on a 0 to 5 Scale, Before and After Suture Removal

| Incision design | Day 5-A | Day 5-P | Day 10 |
|---|---|---|---|
| Crestal | 4.1 | 3.9 | 4.8 |
| Paracrestal | 3.7 | 3.7 | 4.2 |
| Visor | 2.0 | 1.7 | 2.8 |
| Serpentine | 1.4 | 0.8 | 2.1 |

A = prior to suture removal; P = after suture removal.

**Table 3** Group B Radiographic Measurements of Bone Loss (mm)

| Incision design | At placement | Day 10 | Week 16 |
|---|---|---|---|
| Crestal | 0.0 | 0.0 | 0.2 |
| Paracrestal | 0.0 | 0.2 | 1.1 |
| Visor | 0.0 | 0.1 | 2.4 |
| Serpentine | 0.0 | 0.0 | 3.0 |

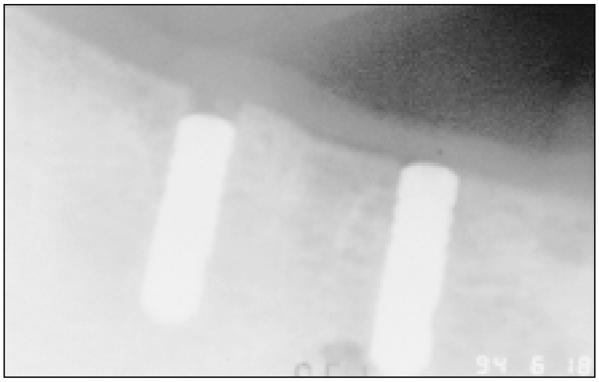

**Fig 4a** The radiographic appearance of two hydroxyapatite-coated implants after surgery.

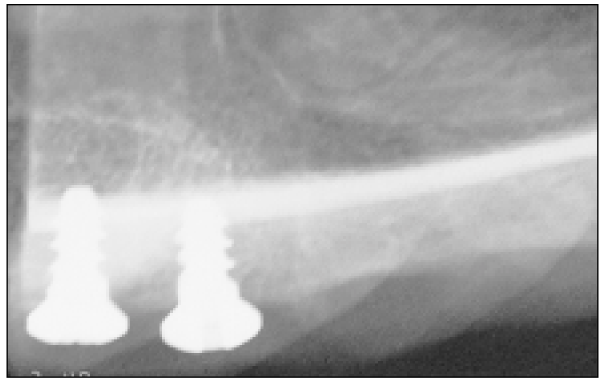

**Fig 4b** The radiographic appearance of two 6 mm screws just after placement (van Gieson's stain; ×8).

veins and common carotid arteries. The cannulas were ligated in place with 0 black silk. A lethal dose of Nembutal was then given, and normal saline was pumped through the head and neck arteriovenous system. When the return was clear, 28% Angiovist was perfused until it too was returned. The catheters were removed and the vessels were ligated. The four jaw quadrants from each animal were resected using a Stryker saw and embedded in (poly)methylmethacrylate monomer. Thirty days later, after hardening, each block was cut into 2-mm slices with a diamond saw and then milled into 40-µm sections. Each section was mounted on a plastic slide, subjected to van Gieson's stain, and examined and documented by photomicrography at 8 × magnification.

## Results

**Clinical Results: Groups A and B.** The crestal incisions showed no bony dehiscence. At suture removal on the fifth day, one mandibular wound demonstrated a 3-mm linear defect with inverted margins. There was moderate inflammation at the suture sites. By the 10th day, all wounds had healed well.

At the paracrestal sites, there were short, interspersed zones of discontinuity after suture removal, but bone could not be seen beneath the incisions. The wound margins were thickened, particularly the buccal components. At two of these sites, flap inversion was noted. However, by the 10th day, healing appeared to be complete and the margins, although thickened, were fully closed. At one paracrestal site in group B, the linea alba was lost during the suturing phase. It had separated spontaneously while grasped in an Adson forceps.

Six of the eight visor incisions had broken down prior to suture removal. Two of these demonstrated bone dehiscence at the buccal margins, and a third showed dehiscence halfway up the ridge on both mesial and distal sides. All but two showed marked edema and rolled-in margins. Suture removal exacerbated the problems, and in group B, three implants became exposed. By the 10th day, however, secondary epithelialization had resulted in clinical improvement with coverage of the hardware in all but one case.

The serpentine incisions fared most poorly. None showed primary healing either before or after suture removal or at the 10th day. Bone was exposed, and although improvement was noted by the 10th day, inverted wound margins were seen. These processes were accompanied by healing with secondary epithelialization. Dehiscent hardware was noted in three of the four sites.

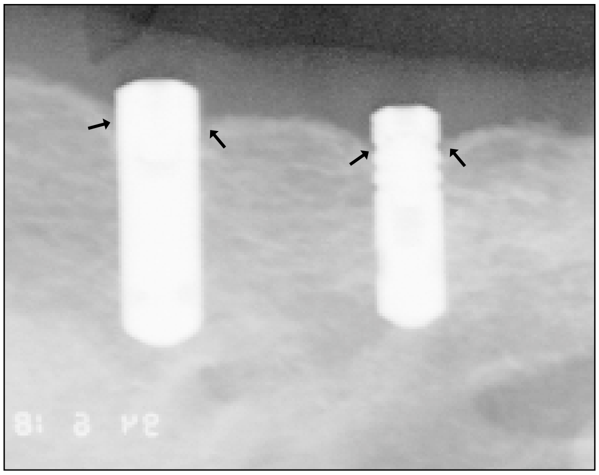

**Fig 5** The radiographic appearance of two hydroxyapatite-coated implants placed beneath a visor incision. Marked bone loss *(arrows)* is visible at the coronal aspects of both implants at 16 weeks.

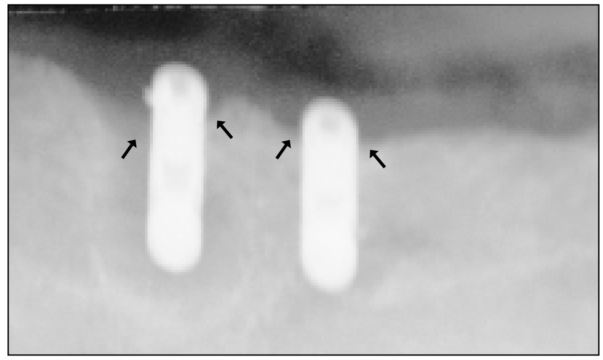

**Fig 6** The radiographic appearance of two hydroxyapatite-coated implants placed beneath an "S" shaped incision. Saucerization of at least 2 mm and as much as 6 mm *(arrows)* is visible at 16 weeks.

Weekly evaluations for the group B animals revealed final healing of the most recalcitrant incisions by the end of the fourth week. From this point until sacrifice at 16 weeks, no unusual sequellae occurred. There was neither loss of implants nor infections or other complications. The clinical ratings for each category are found in Table 2.

**Radiographic Results: Group B.** Group B radiographs taken on the day of implant placement showed the heads of the screws to be level with the maxillary alveolar ridge crests and the implant crevices to be about 1 mm below those levels in the mandibles (Table 3 and Figs 4a and 4b). No changes were seen by the 10th day. Repeat radiographic examinations at the 8th, 12th, and 16th weeks (sacrifice) showed minor changes adjacent to implants placed by crestal and paracrestal incisions (Fig 5). Saucerization phenomena were noted at three of the eight visor-placed implants and at all eight of the serpentine-placed implants (Fig 6). These lesions indicated bone loss of up to 6 mm as measured on films taken using a standardized technique.

**Histologic Results: Control and Group A.** All sections, both control and experimental, showed the presence of an avascular zone directly beneath the linea alba. In the control (Fig 7), vascular channels as outlined by Angiovist were seen in orderly arrangements, originating either from periosteum or from vestibular sources. The crest of the mandibular ridge was well rounded with a nipple of protruding cortex just beneath the avascular zone. There was a large marrow space with well-mineralized bone, low in cellular content. Postextraction gingival integrity was


**Fig 7** The histologic appearance of an edentulous ridge, 12 weeks postextraction, which served as a control and had not been subjected to further investigation. A consistent finding is the avascular zone (z) below the linea alba. Soft tissue viability may be assessed by the quantity and pattern of the vascular channels (a), as outlined by the Angiovist. The alveolar ridge (b) has healed with a nipple and is well rounded with investing mucoperiosteal tissues in intimate contact with its surfaces. The gingiva *(arrow)* has healed well after the extractions and is covered, as expected, by a layer of parakeratin. This control section is the standard by which the experimental sections were compared.

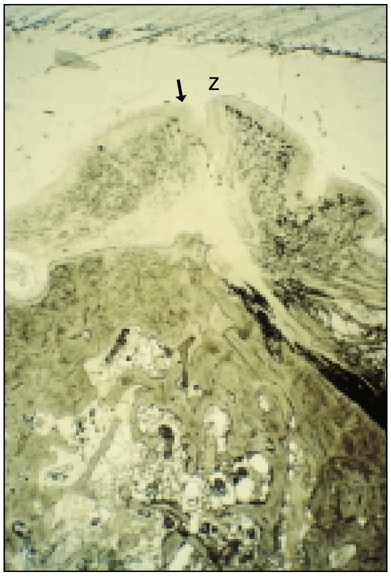


**Fig 8** The appearance of the ridge 10 days after a crestal incision had been permitted to heal. Of interest is the consistency of the avascular zone (z) and the organized status of the vascular channels. The ridge is well shaped, and its overlying soft tissues are in close approximation. The *arrow* indicates the site of the incision.

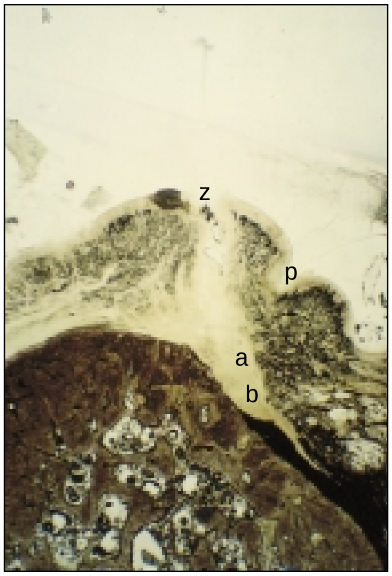


**Fig 9** The paracrestal incision was made 1.5 mm buccal to the linea alba; the loss of some integrity between the incision (p) and the avascular zone (z) is noted. Ridge form is satisfactory. Vascular patterns are relatively undisturbed, but mild bone loss (b) is visible adjacent to a poorly reoriented flap (a), which shows some overlying hemorrhage.

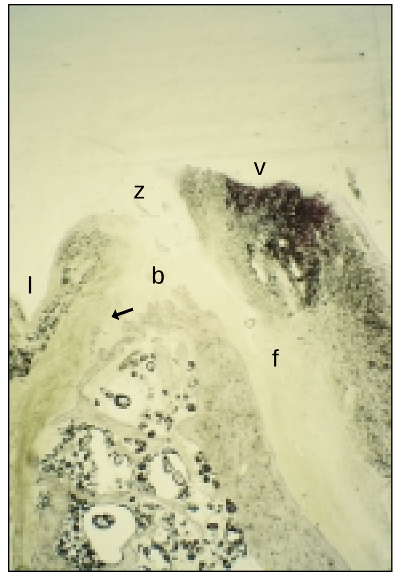


**Fig 10** The visor incision demonstrates hemorrhage and vascular disorientation (v) of the buccal flap, which had been elevated across the ridge (b) to the *arrow*. The lingual tissues, which had not been elevated, show a more orderly vascular pattern (l). The ridge crest has undergone resorption (b). The linea alba and its avascular zone (z) are significant because of their location and relation to the incision type and the flap that had been elevated (f).

virtually flawless, and it was covered with a layer of parakeratin.

The crestal incisions, after 10 days, showed reliable vascular organization, good soft tissue alignment, well-shaped crestal morphology, and the typical avascular zone. The site of the incision indicated its relationship to the avascular zone (Fig 8).

The paracrestal incisions had been made lateral and parallel to the linea alba. Healing was not as complete as compared with the crestal incisions, and there was a less orderly pattern of vessels. Gingival continuity was also less satisfactory. A widened avascular zone was noted beneath the linea alba. The crest was well rounded with a demineralized saucer directly beneath the incision. The remaining bone was well calcified with a healthy marrow space (Fig 9).

The visor incisions, which were based at the lingual surface of the ridge crest, showed significant vascular disorientation and hemorrhage, bone dehiscence, and altered ridge shape. There was resorption beneath the elevated flap that had contributed to narrowed and irregular crests. The mucoperiosteum was related poorly to the buccal surface. The linea alba and underlying avascular zone were visible in the epithelium located directly above the crest of the ridge. The lingual gingival vascular pattern, below the level from which the flaps had been reflected, was relatively unaffected (Fig 10).

The alveolar dehiscence created by the serpentine incisions demonstrated marked alteration of ridge morphology and loss of bone on the surfaces from which the mucoperiosteum had been elevated. The bone surfaces showed resorptive patterns, total vascular disorientation, and flaps without blood supply, which were undergoing necrosis while occupying postures of elevation from the ridge surfaces. The typical avascular zone was seen in the epithelium above the crest at the expected location despite the poor level of healing. The lingual unelevated flaps demonstrated normal vascularity and intimate relationships to the unaffected bony ridges beneath them (Fig 11).

**Histologic Results: Group B.** The presence of the avascular zone was demonstrated with clarity and consistency in sections of the crestal group. Bone density, cervical levels, and ridge form presented evidence of the positive influence of this incision design on the implant host tissues. Bone proliferated over a healing screw. The soft tissue vascular patterns


**Fig 11** This serpentine incision is associated with bone resorption. There is hemorrhage and vascular disarray (v), the flap (f) has failed to close, and the location of the avascular zone (z) appears to have played a pivotal role in the outcome. There is bone resorption beneath the flap (b), whereas on the unelevated lingual side, undisturbed gingivae (l) may be noted.

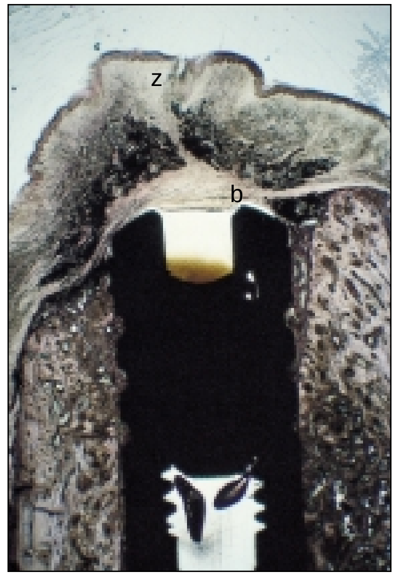


**Fig 12** Hydroxyapatite-coated implants placed beneath crestal incisions show the avascular zone clearly (z). Good bone height is evident around this implant both buccally and lingually. The bone has proliferated above the level of the healing screw (b). This section compares very favorably with the control (Fig 7).


**Fig 13** Bone loss (b) and disoriented or absent vascular channels (v) are consistent findings around implants placed beneath the "S"-shaped (serpentine) incision.

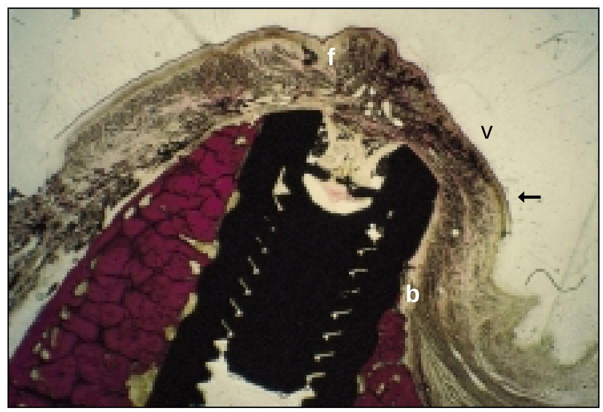


**Fig 14** The consistent findings of the implants placed beneath visor incisions show significant bone loss on the buccal surface (b) with accompanying disorientation of the vascular channels (v). This flap had been elevated beyond the crest to the *arrow*, and the vascular toll taken by this maneuver may be seen at f, the location of the linea alba.

showed some deep hemorrhage, but superficially, well-distributed outlines were in evidence (Fig 12).

Loss of bone contour and height was noted in both mandibular quadrants in which the serpentine incision had been used and in one of them in which the visor incision had been used (Figs 13 and 14). Pericervical bone loss around the implants placed in these quadrants, from 30% to 50%, was found beneath the elevated flaps. Dramatic stability was noted with consistency on the contralateral unele-


**Fig 15** The bone (b) grew over this hydroxyapatite-coated implant, which had been placed beneath a crestal incision.

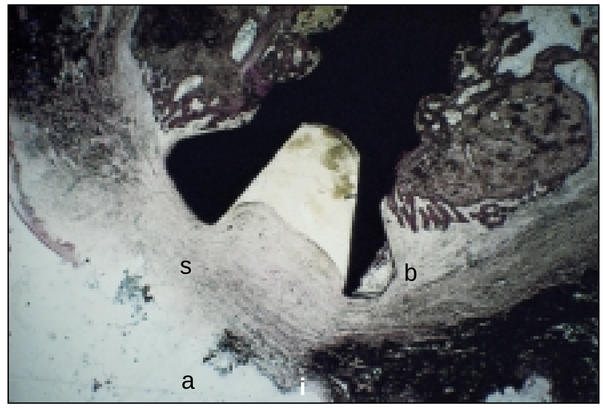


**Fig 16** This 6 mm screw, placed in the maxilla beneath this paracrestal incision, showed slight bone loss on the buccal side (b). The incision (i) had been made to the buccal side of the linea alba (a), which had been lost at the time of suturing. This would account for the crestal avascular scar (s).


**Fig 17** The vascular supply and gingival orientation (v) over this implant, placed beneath a paracrestal incision (i), are well oriented. In addition, bone preservation is evident, with slight loss on the affected side (b). Note the relationship of the linea alba (l) to the incision site (i).

vated sides that had contained the lineae alba. The quality of the elevated gingivae as compared with that covering the unaffected bone was also altered, either by vascular disarray (Fig 13) or by marked hemorrhage (Fig 14). The homogeneity and quality of the bone surrounding implants placed beneath the crestal and paracrestal incisions were found to be most like those of the untreated control in both mandibular (Fig 15) and maxillary specimens. Some bone loss, accompanied by overlying hemorrhage, was noted on the paracrestal specimen to the buccal side of the linea alba (Fig 16). Absence of the avascular zone is likely the result of the accidental loss of the linea alba that was grasped with an Adson forceps during closure.

Figure 17 illustrates a section of mandible containing an implant placed beneath a paracrestal incision. The vascular pattern is reasonably unaffected as compared with the control. Bone levels on both buccal and lingual surfaces are high, although there is slight loss on the buccal side.

## Discussion

Clinical experiences have offered evidence of a crestal avascular zone and the role it might play in the primary healing of flaps designed with novel incisions. Paracrestal incisions (often made unintentionally) may present the surgeon with a thin strip of detached avascular tissue, as was the result in Fig 16. Having noted these findings clinically, the role of this avascular zone was evaluated in its relationship to the healing processes of ridges with incisions made of varying designs.

In oral surgery, it has been classic practice to design incisions that will not be placed over bone defects. If a cystectomy is to be performed, its outline should determine the occult location of the incision. This principle probably influenced the introduction of noncrestal incisions. The results of the research described in this paper indicate that such incisions may be responsible for retarded healing, dehiscent bone, and alterations of ridge morphology. The cause of these morbid findings appears to be a loss of viability of those areas of the flap lying between the crestal avascular zone (linea alba) and the incision. This was confirmed by the manner in which vascular patterns were influenced by incision location. Examination of the histologic sections demonstrated the presence of hemorrhage or vascular disorientation of the soft tissues overlying zones of bone loss beneath them. Note, for example, the sites labeled "V" in Figs 14, 16, and 17. Although not quantified, the relationship appears with a consistency that certainly minimizes the possibilities of coincidence. Another factor that might cause changes in bone morphology is that the lengths of novel incisions are greater than crestal designs, thus exposing the soft tissues to more trauma and the underlying bone to greater areas of elevated periosteum. Although the damage may be a reversible process depending on the maintenance of the collagen matrix, prompt palliative measures must be taken or the bone loss will become permanent.

The integrity of the soft tissues that invest implant-supported alveolar ridges in dogs plays a role in determining the maintenance of the host sites and the prognosis of their prostheses. An important determinant of flap viability and the efficiency of primary healing is the vascular amount of gingivae, particularly in relation to the crestal avascular zone. That zone, which is consistent, should govern the design and location of incisions made for the purpose of exposing the ridge for the placement of implants. These phenomena, it must be emphasized, were observed in dogs. Although supporting the soft tissue findings described in this study, recent contributions to the literature failed to note any effects on the underlying host bone.[2,3] This omission could be attributed to the absence of histologic studies, to different factors that may contribute to the healing process in humans, or to more assiduous postoperative care.

Although the number of quadrants in this study was small (four per incision), correlation of bone morphology alterations was established consistently with each poorly healed flap. As a result, speculation arose as to how well bone-borne implants beneath such flaps might fare. This prompted a subsequent investigation. The outlined microvasculature was shown to have been influenced in this series by incision design. The viability of the elevated mucoperiosteal flaps was determined by the location of the avascular zones. The quantity and location of bone loss was found to be in direct relation to flap elevation and microvascular distribution.

## Conclusion

In dogs, there are avascular zones beneath and linea albas in edentulous ridges. Crestal incisions create the most predictable levels of primary soft tissue healing. Novel incisions (paracrestal, visor, serpentine) may impede primary healing and may cause the loss of alveolar bone found beneath them. In this study, endosseous implant bone support was affected by incision design. In dogs, dentoalveolar surgery planned for edentulous areas should be performed by making midcrestal incisions.

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