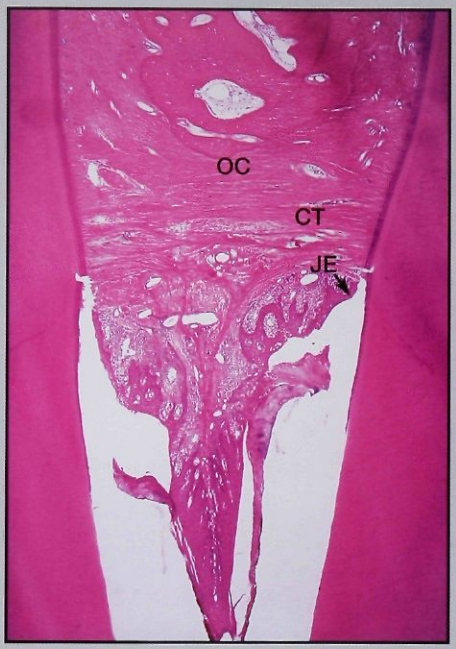
OC
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CT

Formation of the Biologic Width Following Crown Lengthening in Nonhuman Primates

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The purpose of this study was to determine if and how the biologic width is reestablished following surgical crown lengthening. Crown-lengthening surgery was performed on the right or left maxillary and mandibular central and lateral incisors of three adult monkeys, with contralateral teeth serving as unoperated controls. Twelve weeks after surgery, tissue blocks were removed for histologic analysis. The results of a histometric evaluation indicate that the biologic width is reestablished following surgical crown lengthening. The junctional epithelium generally migrates to the apical level of root planing. Space for the supracrestal connective tissue fiber groups is created by crestal resorption of alveolar bone. (Int J Periodontics Restorative Dent 1999;19:529–541.)

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A crown extension involves the surgical removal of soft and hard periodontal tissue to gain clinical crown length. Crown lengthening is done to facilitate caries removal, restoration of a tooth without violating the biologic width, restoration retention, esthetics, and impressions, and to manage root sensitivity.[1–3]

Biologic width is a term coined by Cohen in 1962[4] based on the work of Gargiulo et al.[5] They measured the component parts of the dentogingival junction of normal human autopsy specimens (30 jaws, 287 individual teeth, 325 surfaces). The mean measurements were a sulcus depth of 0.69 mm, a length of epithelial attachment of 0.97 mm, and a length of supracrestal connective tissue of 1.07 mm.[5] The supracrestal connective tissue showed the most constant values, although there were large ranges for all 3 structures. These mean measurements form the basis for the biologic width.

There is some controversy as to what the term biologic width

encompasses. Assif et al[2] define the biologic width as the total dimension of the epithelial and connective tissue attachment to the root and refer to the study by Gargiulo et al,[5] where it was determined that this dimension averages 2.04 mm. Nevins and Skurow[3] define biologic width as a combined sum of the space occupied by the supracrestal fibers, junctional epithelium, and the gingival sulcus, and estimate that these measure a minimum of 3 mm.

It has been hypothesized by several authors that impingement of a restorative margin into the biologic width will produce an inflammatory response, resulting in loss of bone and connective tissue attachment and migration of the epithelial attachment.[3,6–12] A common consensus is that, when the biologic width is violated, the body will attempt to redefine it by a process of osseous resorption. It is theorized that this process frequently leads to chronic inflammation and periodontitis.[1] Supporting this hypothesis is the fact that subgingival margins cause greater gingival inflammation and bone loss than margins placed in a more coronal position.[3,13–18]

There is a range of supracrestal tooth exposure recommended during crown-lengthening surgery. Ingber et al[4] and Fugazzotto[19] recommend 3 mm of supracrestal tooth structure to allow for biologic width formation and retention of the prosthesis; Assif et al[2] recommend 4 mm. Wagenberg et al[20] recommend a 5- to 5.25-mm exposure of supracrestal tooth structure. The constant adherence to fixed measurements for the biologic width ignores the variable nature of this entity from tooth to tooth and person to person.[8]

It appears that crown-lengthening surgery may alter the dimensions of the biologic width. It has been noted that following osseous surgery and apically positioned flaps, there is a reduced distance from the gingival margin to the apical end of the junctional epithelium.[21]

Various authors have noted that resorption of the osseous crest occurs after ostectomy. Levine and Stahl[22] noted slight crestal absorption that created space for insertion of transeptal fibers. Aeschlimann et al[23] demonstrated a mean crestal resorption of 0.22 mm. Wilderman et al[24] found an initial postoperative resorption of 1.2 mm, followed by 0.4 mm of alveolar bone repair for a total mean loss of 0.8 mm. These findings are consistent with those reported by Caton and Nyman,[21] who demonstrated that osseous surgery results in a significant loss of interdental crestal bone height.

In a denudation procedure followed by tooth preparation to the level of the bone crest, there was 1 mm of crestal resorption that created space for a new system of transeptal fibers. Nonprepared controls had no

such crestal resorption. The authors felt that this demonstrated the importance of allowing room for biologic width.[25]

To date, no one has described the dimensions of dentogingival junction wound healing following crown-lengthening procedures in nonhuman primates. The aim of this research is to determine if the biologic width is reestablished following crown-lengthening surgery.

Method and materials

The study was performed using 3 young adult male Rhesus monkeys (Macaca mulatta) weighing between 7 and 10 kg. All animals had a complete and intact complement of permanent teeth. The animals were fed standard monkey chow and water ad libitum, supplemented with fresh fruit. Postsurgically, the monkey chow was softened with fruit juice and the fruit mashed to avoid trauma to the surgical sites. This modified diet was continued until the end of the experiment.

For all procedures the animals were sedated with ketamine hydrochloride 10 mg/kg body weight. For surgical procedures the animals were intubated, and general anesthesia was obtained with isofluorane gas. During surgical procedures fluid volume was maintained with lactated Ringer solution given intravenously. Postsurgical analgesia was obtained with acetaminophen suspension 10 mg/kg body weight given orally every 8 hours as needed. When necessary, buprenorphine (Buprenex, Reckitt & Colman, 0.01 to 0.04 mg/kg subcutaneously daily) was administered. Bicillin L-A 300,000 IU/mL (sterile penicillin G benzathine suspension, Wyeth-Ayerst) 43,000 IU/kg body weight was administered by deep intramuscular injection at the time of surgery and every 14 days until the end of the experiment to prevent infection.

No oral hygiene was performed until 2 weeks prior to surgery. At that time, plaque control consisting of toothbrushing with 2% chlorhexidine gluconate and flossing was instituted 3 times a week. After surgery, plaque control consisted of cleaning the gingival margin with a cotton-tipped applicator soaked with 2% chlorhexidine gluconate 3 times a week. Interproximal cleaning of experimental teeth was performed with interdental brushes dipped in 2% chlorhexidine gluconate. This method of plaque control has been shown to eliminate clinical signs of gingivitis in this species.[26] This plaque control regimen was continued until the end of the experiment.

The quadrant of crown lengthening was randomly selected, with the contralateral teeth serving as an unoperated control (Fig 1). Aseptic surgical techniques were practiced for all surgeries.

Under general anesthesia, sulcular and submarginal incisions were made from the distal aspect of the lateral incisor to the mesial aspect of the corresponding central incisor, both facially and lingually/palatally. Vertical releasing incisions were placed at each end of the incisions and mucoperiosteal flaps were reflected, exposing the alveolus (Fig 2). Rotary and hand instruments were used to remove supporting interproximal, facial, and lingual/palatal alveolar bone over the experimental teeth. Enough bone was removed to create a distance of 4 to 6 mm from the cementoenamel junction (CEJ) to the alveolar crest, which was verified with a periodontal probe. The roots of these teeth were thoroughly planed to remove all periodontal ligament and cementum from the crest of bone to the CEJ (Fig 3). The flaps were placed apical to their original position and secured with # 4.0 silk sutures, leaving a denuded osseous crest interproximally (Fig 4). The sutures were removed 1 week following the surgery. The animals were euthanized with a lethal intravenous dose of sodium pentobarbital 60 mg/mL 12 weeks after surgery.

Immediately after euthanasia, the animals were perfused with 10% neutral buffered formalin. The jaws were then dissected free and prepared by routine laboratory methods to produce mesiodistal step serial sections 6 μm in thickness at 144-μm

Fig 1a (left) *Preoperative facial view shows healthy gingiva.*

Fig 1b (right) *Preoperative palatal view shows healthy gingiva.*

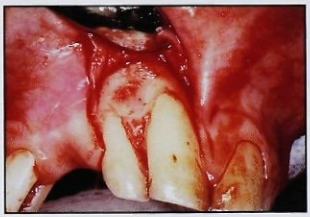
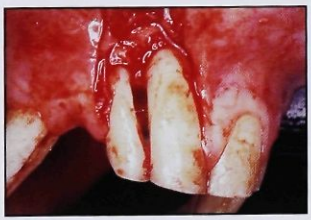


Fig 2a (left) *Facial view shows reflection of full-thickness flap and osseous architecture prior to crown lengthening.*

Fig 2b (right) *Palatal view shows reflection of full-thickness flap and osseous architecture prior to crown lengthening.*



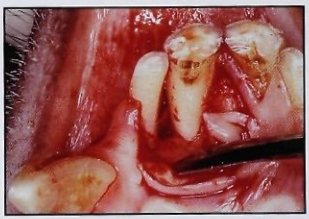


Fig 3a (left) *Facial view after ostectomy and root planing.*

Fig 3b (right) *Palatal view after ostectomy and root planing.*

Fig 4a (left) *Facial view shows periosteal sutures and an apically positioned flap. Osseous crest has been left exposed.*

Fig 4b (right) *Palatal view shows periosteal sutures and an apically positioned flap.*

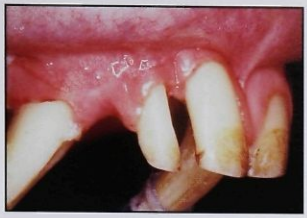


Fig 5a (left) *Facial view at time of sacrifice. Tissues remain apically positioned and appear healthy.*

Fig 5b (right) *Palatal view at time of sacrifice.*

intervals that were stained with hematoxylin-eosin.

Histometric analysis was performed by an examiner blinded to all aspects of the study, using an Olympus VH2 microscope interfaced with a 166 MHz computer equipped with Optima 6.1 image-analysis software. The most central section of each tooth was identified by the size of the root canal. This section and 2 step serial sections on either side were subjected to histometric analysis. Linear measurements were made along the surface of the roots. The osseous crest was used as the primary reference point. The distances measured included: bone crest to crest of gingiva, bone crest to the apical extent of the junctional epithelium, the crest of gingiva to the apical extent of the junctional epithelium, and apical level of root planing to bone crest.

Errors of the methods

The examiner was blinded to the protocol of the study and all sections were masked to prevent bias. The error of the method was determined by calculating correlation coefficients for duplicate measures of each parameter. The correlation coefficients averaged above 0.95 for all parameters measured. This was deemed acceptable for the purposes of this study.

Results

Clinical observations

The animals remained healthy for the entire course of the experiment. Preoperative scaling and plaque control greatly reduced gingival redness, swelling, and bleeding.

Following suture removal at 1 week postsurgery, the gingival margins remained apically displaced. The associated gingiva was red and swollen and there were localized areas of bleeding. At this point, healing was advanced enough to allow gentle mechanical plaque removal. Only localized areas showed residual redness and swelling 2 weeks following surgery. The gingival margin remained in its apical position. At 4 weeks, healing appeared to be complete, and the gingivae remained knife edged and pink until the time of sacrifice (Fig 5).

Healing of the mandibular surgical sites appeared to lag 1 week behind their maxillary counterparts. From 5 weeks until sacrifice there was little change in the gingival appearance. In all cases the gingival margins remained apically displaced. Localized calculus deposits were removed as they formed.

Histologic observations

Both control and experimental sites had inflammatory cell infiltration, but this was more extensive at control sites (Fig 6). The apical termination of the junctional epithelium was at the CEJ or on cementum at all control sites and on the cementum at experimental sites. Supracrestal connective tissue fibers and periodontal ligament fibers inserted

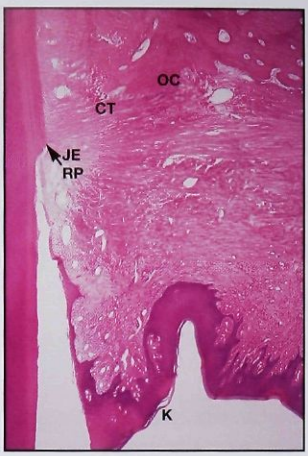


Fig 6a (left) *Maxillary control site shows presence of inflammatory cell infiltration. The supracrestal connective tissue* (CT) *is functionally oriented perpendicular to the root surface and is interposed between the osseous crest* (OC) *and the apical end of the junctional epithelium* (JE). *(Original magnification × 40; mesiodistal section stained with hematoxylin-eosin.)*

Fig 6b (right) *Maxillary experimental site in which junctional epithelium* (JE) *extends to the apical level of root planing* (RP). *Resorption of osseous crest* (OC) *has created space for the functionally oriented supracrestal connective tissue* (CT). *Keratinization* (K) *is at the crest of the gingiva. (Original magnification × 80; mesiodistal section stained with hematoxylin-eosin.)*

perpendicular to the cementum (Figs 7 and 8). The gingival crests of the experimental sites were broader and flatter than their control counterparts. Keratinization was present on most experimental specimens (Fig 6b).

The apical level of root planing was clearly visible at experimental sites (Fig 9). Two of the mandibular experimental sites experienced a significant amount of regeneration. These sites were incompletely root planed (Fig 10).

The dimensions of the supracrestal soft tissues are listed in Table 1. This measurement includes the sulcus, junctional epithelium, and supracrestal connective tissue attachment. In maxillary sites, crown lengthening effected a mean reduction of this dimension (control 2.25 mm vs experimental 1.56 mm). Mandibular sites showed increased width of supracrestal tissue following crown-lengthening surgery. This increase was present for monkeys 1 and 3. Monkey 2 followed the trend set by maxillary sites.

Table 2 shows the combined width of the sulcular and junctional epithelium. Maxillary control sites had a mean width of 1.23 mm, which is smaller than the mean mandibular control site measurement of 1.53 mm. Healing following crown lengthening in maxillary sites tended to result in a reduced width of epithelium (mean 0.94 mm), whereas mandibular sites tended to heal with a longer junctional epithelium, creating an increased width (1.75 mm).

A supracrestal connective tissue was interposed between the junctional epithelium and the osseous crest in all cases. When compared, the maxillary and mandibular control sites had similar mean dimensions of 1.02 and 0.96 mm, respectively. The width of the supracrestal connective tissue was reduced in both maxillary and mandibular experimental sites (Table 3), with mean measurements of 0.63 and 0.86 mm, respectively. Greater reduction was found at the maxillary sites. Monkeys 1 and 3 had significant regeneration at the mandibular sites. This created a situation in which the osseous crest was coronal to the apical level of root planing (Table 4). The regeneration was associated with root surfaces that had received incomplete root planing. The mandibular central incisor of monkey 2 and the lateral incisor

Fig 7a (left) *Maxillary control site shows the apical termination of the junctional epithelium* (JE) *and osseous crest* (OC). *(Original magnification × 100; mesiodistal section stained with hematoxylin-eosin.)*

Fig 7b (right) *Maxillary control site at higher magnification shows the functional orientation and insertion of the supracrestal connective tissue* (CT) *fibers. (Original magnification × 200; mesiodistal section stained with hematoxylin-eosin.)*

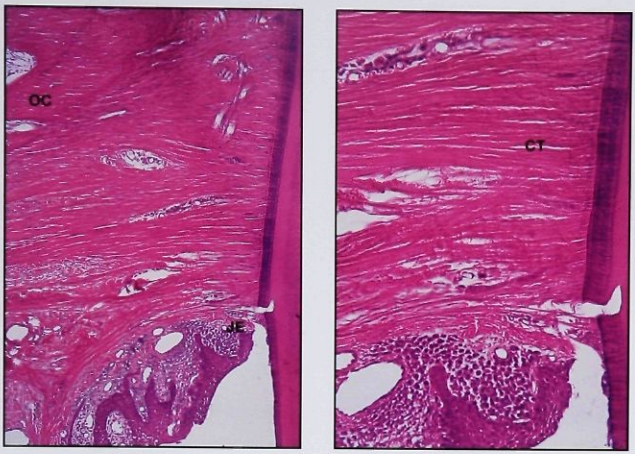


Fig 8 *Maxillary experimental site at high magnification demonstrates the functional orientation and insertion of the supracrestal connective tissue fibers* (CT). *Note the similarity in appearance to the control specimen in Fig 7b. (Original magnification × 200; mesiodistal section stained with hematoxylin-eosin.)*

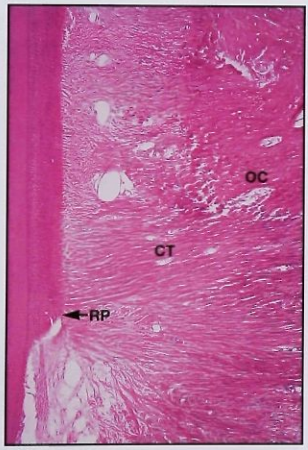


Fig 9 *Experimental site shows the apical terminus of the junctional epithelium extending to the apical level of root planing* (RP). *Resorption of the osseous crest* (OC) *has created space for supracrestal connective tissue* (CT). *(Original magnification × 100; mesiodistal section stained with hematoxylin-eosin.)*

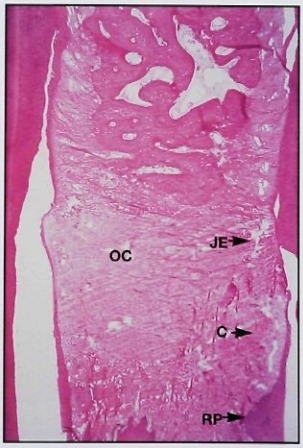


Fig 10 *Maxillary experimental site demonstrates regeneration and new cementum* (C) *following inadequate root planing.* RP = *apical level of root planing;* OC = *osseous crest;* JE = *apical end of junctional epithelium. (Original magnification × 40; mesiodistal section stained with hematoxylin-eosin.)*

Table 1 Supracrestal soft tissue: Distance between bone crest and gingival margin (mm)

	Maxilla		Mandible	
Tooth	Experimental	Control	Experimental	Control
Monkey 1				
Central incisor	1.81	2.26	2.52	2.01
Lateral incisor	1.81	2.69	2.45	2.10
Mean	1.81	2.47	2.49	2.06
Monkey 2				
Central incisor	1.45	2.55	3.17	3.24
Lateral incisor	1.31	2.58	3.16	3.24
Mean	1.38	2.57	3.17	3.24
Monkey 3				
Central incisor	1.41	1.72	2.22	2.20
Lateral incisor	1.62	1.73	2.16	2.21
Mean	1.51	1.72	2.19	2.20
Mean ± SD	1.56 ± 0.21	2.25 ± 0.43	2.62 ±0.45	2.50 ± 0.58
Range	1.81 to 1.31	2.69 to 1.72	3.17 to 2.16	3.24 to 2.01

SD = standard deviation.

Table 2 Sulcular and junctional epithelium: Distance between gingival margin and apical end of junctional epithelium (mm)

	Maxilla		Mandible	
Tooth	Experimental	Control	Experimental	Control
Monkey 1				
Central incisor	1.21	0.67	1.67	1.35
Lateral incisor	1.04	1.97	1.52	1.35
Mean	1.13	1.32	1.60	1.35
Monkey 2				
Central incisor	0.97	1.35	2.04	1.39
Lateral incisor	0.59	1.64	1.94	2.26
Mean	0.78	1.49	1.99	1.83
Monkey 3				
Central incisor	0.54	0.93	1.38	1.38
Lateral incisor	1.27	0.84	1.95	1.49
Mean	0.91	0.89	1.66	1.43
Mean ± SD	0.94 ± 0.31	1.23 ± 0.51	1.75 ±0.27	1.53 ± 0.36
Range	1.27 to 0.54	1.97 to 0.67	2.04 to 1.38	2.26 to 1.35

SD = standard deviation.

Table 3 Supracrestal connective tissue: Distance between bone crest and apical end of junctional epithelium (mm)

	Maxilla		Mandible	
Tooth	Experimental	Control	Experimental	Control
Monkey 1				
Central incisor	0.60	1.59	0.85	0.67
Lateral incisor	0.77	0.71	0.94	0.75
Mean	0.68	1.15	0.89	0.71
Monkey 2				
Central incisor	0.48	1.20	1.13	1.85
Lateral incisor	0.72	0.95	1.21	0.98
Mean	0.60	1.07	1.17	1.41
Monkey 3				
Central incisor	0.87	0.79	0.84	0.82
Lateral incisor	0.34	0.89	0.21	0.72
Mean	0.61	0.84	0.53	0.77
Mean ± SD	0.63 ± 0.19	1.02 ± 0.32	0.86 ±0.35	0.96 ± 0.45
Range	0.87 to 0.34	1.59 to 0.71	1.21 to 0.21	1.85 to 0.67

SD = standard deviation.

Table 4 Crestal bone resorption: Distance between apical level of root planing and bone crest (mm)

Tooth	Maxillary distance	Mandibular distance
Monkey 1		
Central incisor	0.47	0.13
Lateral incisor	0.69	1.48
Mean	0.58	0.81
Monkey 2		
Central incisor	0.41	1.27
Lateral incisor	0.75	1.22
Mean	0.58	1.24
Monkey 3		
Central incisor	0.37	1.19
Lateral incisor	0.31	−0.68
Mean	0.34	0.26
Mean ± SD	0.50 ±0.18	0.77 ± 0.85
Range	0.75 to 0.31	1.48 to −0.68

SD = standard deviation.

of monkey 3 were thoroughly root planed, and their dimensions followed the trends set at maxillary sites.

The width of supracrestal connective tissue tended to correlate with the amount of crestal resorption (Table 4). Maxillary sites had a mean resorption of 0.50 mm. Although the mandibular mean resorption of 0.77 mm appears similar to the maxillary sites, closer inspection reveals a range of 2.5 mm. The variability was accounted for by the variability of root planing and subsequent regeneration in certain areas. An example of this variability is a site that had regeneration of the osseous crest coronal to the apical level of root planing (Table 4).

Discussion

The purpose of this study was to determine the nature of the biologic width following surgical crown lengthening. Our findings indicate that healing following osseous crown-lengthening surgery results in a junctional epithelium that extends to the apical level of root planing. Postsurgical resorption of the osseous crest created space for supracrestal connective tissue with functional alignment perpendicular to the cementum surface. The total height of supracrestal tissue appeared to be reduced compared to the control side. These results indicate that a reduced biologic width is reestablished apically following crown-lengthening surgery. These findings are consistent with those reported by Caton and Nyman.[21] In their study, it was demonstrated that following osseous surgery the total dimension of supracrestal tissue was moved apically on the root surface and consisted of a sulcus, junctional epithelium, and supracrestal connective tissue. They also reported a reduced distance from the crest of the gingiva to the apical extent of the junctional epithelium. Furthermore, they demonstrated that osseous surgery resulted in a significant loss of connective tissue attachment and loss of interdental crestal bone height.[21]

Our observations indicate that the significance of this crestal resorption is to create room for the supracrestal fiber attachment. Carnevale et al[25] had similar findings to this study working with dogs. The purpose of their study was to determine the tissue response to various restorative margin preparations created to the osseous crest. Using a split-mouth design, osseous denudation was performed, followed by various restorative margins created to the level of the osseous crest. They found that there was approximately 1 mm of crestal bone resorption that was replaced by transeptal fibers. They also found apical migration of the junctional epithelium to the apical level of root planing. This resorption of bone may indicate the importance of maintaining room for the biologic width.[25]

In analyzing the data, it was important to completely blind the examiner to the purpose of the study as well as to the material he was analyzing. This was necessary because the surgeries created results that were dramatic enough to identify the experimental and control sites. Thus, the methods of measurement eliminated a source of potential bias.

Common fixed reference points used in research are the CEJ and the apical level of root planing. Neither of these references existed in either the experimental or control groups. The surgical procedure elongated the crowns to such an extent that the CEJs were not visible in the histologic specimens. The control group by its nature had no

apical level of root planing. Because of these limitations, the osseous crest was used as a reference to determine the dimensions of the supracrestal tissues. It was necessary to measure the apical level of root planing of the experimental sites to determine the relationship between the osseous crest and the instrumented root surface because roots were instrumented to the crest of bone during the surgery.

The importance of thorough root planing during resective surgery was demonstrated in this study. Teeth subjected to incomplete root planing experienced a significant amount of regeneration. Similar results were found on teeth adjacent to incompletely root planed teeth. Others have found that gingival denudation without root planing resulted ultimately in no loss of connective tissue attachment level.[22,27]

Crestal resorption following osseous surgery has been demonstrated previously. Donnenfeld et al[28] noted that osseous grinding resulted in a greater loss of alveolar bone and connective tissue attachment level than did flap curettage. Pennel et al,[29] using a reentry procedure to assess bone height, found that after osseous surgery there was a mean loss of crestal bone of 0.63 mm. Wilderman et al[24] found that postoperatively there was a mean crestal resorption of 1.2 mm. Over 1.5 years there was a gradual repair of the alveolar crest of 0.4 mm. This resulted in a mean total loss of 0.8 mm. In their study, only minimal amounts of root surface were removed and the flap was replaced coronal to the osseous crest, which may be why there was repair of the osseous crest.[24] Our study was performed with vigorous and thorough root planing and the flap margin was placed at the osseous crest, allowing interdental denudation. It is possible that this arrangement prevents coronal repair of the bone height. Alternatively, the 3-month healing time may not have been long enough for a gradual repair of the osseous crest.

Our research examined the interproximal areas. Based on the findings of Wilderman et al[24] and Moghaddas and Stahl,[30] who showed that the quantity of bone resorption is dependent on the thickness of the bone with the greatest resorption in areas of thin bone, it is possible that crown-lengthening surgery on the facial and lingual surfaces results in a wider biologic width than interproximal surgery.

Over the years, various authors have used the measurements described by Gargiulo et al[5] to recommend the amount of osseous reduction necessary during crown-lengthening surgery. Their study showed that during passive eruption the connective tissue attachment component of the attachment complex remained stable, with a mean of 1.07 mm.[5] To create adequate space for the connective tissue attachment, epithelial attachment, sulcus, and tooth structure for margin placement, tooth exposures of between 3 and 5 mm have been proposed. In a clinical study, Van Der Velden[27] found that interdental denudation without root planing resulted in no loss of alveolar bone height. That study reported that the supracrestal tissues reformed to the same dimensions that were found prior to surgery. These findings were used to recommend that crown-lengthening procedures create a distance of 5 mm from the proposed margin of the restoration to the alveolar crest.[27] Fugazzotto[19] differs from this approach and recommends 3 mm from the osseous crest to the proposed restorative margin. Many of these studies assumed that the supracrestal connective tissue would reform coronal to the apical level of root planing, and consequently recommended a greater exposure of tooth structure to allow for this. Within the confines of our present research, we show that this is not the case. To estimate the amount of supragingival tissues that will reform, Smuckler and Chaibi[31] recommend approximating the measurements prior to surgery. Our results show that reliance on this method will overestimate the amount of exposed supracrestal tooth structure necessary. Thorough scaling and root planing during crown-lengthening surgery will enable the practitioner to accurately determine the superior termination of the

supracrestal connective tissue. Failure to perform thorough scaling and root planing will result in regeneration of the tissues that may necessitate retreatment. Our results agree with other researchers who demonstrated that no net loss of tissue resulted from denudation without root planing.[22]

Based on the results of our study and the findings of Carnevale et al,[25] it seems that exposure of the osseous crest combined with thorough scaling and root planing will result in resorption of crestal bone. This resorption is important in maintaining supracrestal connective tissues between the junctional epithelium and bone.

In a recent publication, Leichter et al[32] showed that linear measurements misrepresent the true tissue response following regenerative techniques. They further questioned the use of computer-assisted histomorphometric analysis, stating that because the monitor gives poor resolution of the tissue types, there is poor correlation between conventional stereology and computer-assisted histomorphometric analysis.[32] These issues were addressed by our research. First, by its nature biologic width is a linear measurement. The majority of wound healing research has made these measurements. Furthermore, the principle of biologic width is based on a linear measurement coronal to the osseous crest. Failure to present our material in a linear manner would have resulted in a lack of applicability to the statements made by other investigators. Second, to protect against inaccurate measurements caused by the drawbacks of monitor resolution, all landmarks were assessed and confirmed through the microscope attached to the monitor prior to making the measurements.

The limited number of subjects in this report prevented a finite analysis. However, under the scope of this research it was concluded that a reduced biologic width was formed following crown-lengthening surgery. The formation of functionally oriented transeptal fibers was facilitated by the resorption of osseous crest apical to the level of root planing.

Conclusions

Following the crown-lengthening procedure in nonhuman primates described above

1. The biologic width is reestablished;
2. The junctional epithelium generally migrates to the apical level of root planing; and
3. The supracrestal connective tissue regenerates in the area of postoperative crestal resorption.

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