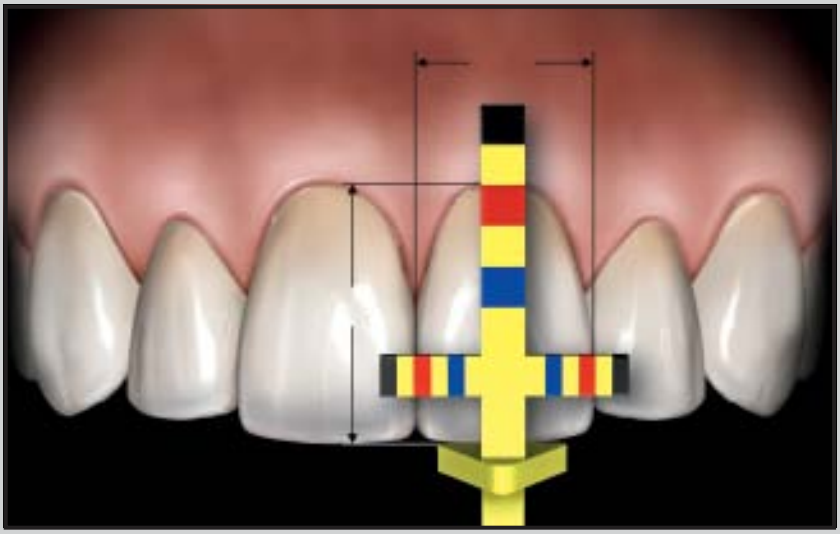

Biologic Rationale of Esthetic Crown Lengthening Using Innovative Proportion Gauges

*Paul Fletcher, DDS**

Research shows that practitioners tend to underestimate the amount of tooth structure that must be exposed during a crown lengthening procedure. In the anterior portion of the mouth, this can lead to biologic width problems and subsequent cosmetic issues. This paper presents a biologically based, step-by-step approach to periodontal esthetic crown lengthening. Using a series of innovative measuring gauges, the ideal clinical crown length of a tooth as well as the proper occlusogingival placement of the interproximal papilla will be determined based on established, documented tooth proportion relationships. The biologic crown length of the tooth, defined as the distance from the incisal edge to the bone crest, will subsequently be determined as a function of the clinical crown length, with the ultimate goals being adequate tooth structure for the placement of a restorative margin, establishment of a healthy dentogingival complex, and the placement of an esthetically pleasing definitive restoration. (Int J Periodontics Restorative Dent 2011;31:523–532.)

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Periodontal crown lengthening is performed to reduce excess tissue and encompasses the recontouring and removal of gingiva or gingiva and bone to increase the length of the clinical crown when inadequate solid tooth structure is available to place a crown margin with proper retention and resistance form. Most often this is a result of extensive caries, crown fracture, faulty pre-existing margins, or failed restorations. Additionally, it is performed to correct gingival asymmetries and to reposition the dentogingival complex as an adjunct to esthetic restorative procedures. In conjunction with an increase in clinical crown length, the procedure involves a concurrent increase in the biologic crown length, defined as the distance from the margin of sound tooth structure to the crest of bone.[1] Rosenberg et al[2] stated that this therapeutic modality was performed predominantly to fulfill the requirements of the restorative dentist related to esthetics, marginal seal, retention, and form and function, and it was integral in determining the success of the definitive restoration.

There is a lack of consensus regarding the amount of tooth structure that must be exposed above the crest of bone for restorative purposes.[3–8] This paper presents a biologically based, step-by-step approach to periodontal esthetic crown lengthening using a series of innovatively designed, color-coded measurement gauges. The ideal clinical crown length of a tooth will be determined based on established tooth proportion relationships. The proper biologic length of the crown will subsequently be determined as a function of the clinical length, as will the proper occlusogingival placement of the interproximal papilla. The presence of adequate tooth structure for the placement of a restorative margin, establishment of a healthy dentogingival complex, and the subsequent fabrication of a well-fitting, esthetically pleasing definitive restoration are the ultimate goals.

The recognition and identification of the components of biologic width have been defined over time.[1–4,9,10] Gargiulo et al[9] used human autopsy material to record an average measurement of 2.73 mm, comprising 0.97 mm for the epithelial attachment, 1.07 mm for the connective tissue, and 0.69 mm for the sulcus depth. In clinical studies, the superosseous keratinized gingiva in the esthetic zone was found to average 3.6 mm,[11] with a probing depth of 3.0 mm on the midfacial aspect of the maxillary central incisors and 3.0 to 4.5 mm interproximally.[12]

These findings were confirmed histologically, and, additionally, a postsurgical reduction of the components of the attachment apparatus was demonstrated.[13–15] The junctional epithelium will migrate to the osseous crest if the root planing extends to that level, but when supercrestal fibers from the periodontal ligament are retained, they may reconnect with the connective tissue fibers from the flap.[16]

When all attachment fibers are removed during surgery, 0.4 to 1.0 mm of crestal resorption occurs, exposing ligament fibers that will mesh with connective tissue fibers from the inner aspect of the flap to establish a new supracrestal connective tissue fiber barrier beneath the reformed junctional epithelium.[13,17] This connective tissue fiber barrier prevents further apical migration of the junctional epithelium, and its blood supply supports the newly formed attachment apparatus.

The consensus of opinion is that at least 2 mm of exposed tooth structure is needed for crown retention.[18] Adding this number to a mean junctional epithelial length of 0.97 mm and a mean connective tissue fiber barrier of 1.07 mm, it would seem that, ideally, at least 4.0 mm of superosseous tooth structure must be available for the placement of a restorative crown margin and for the establishment of an attachment apparatus. If less is present, retention may be compromised or the biologic width impinged upon. In the esthetic zone, additional considerations must be addressed. If a crown margin is exposed, the restoration is usually considered to be less than ideal. Additionally, a noticeable "reddish" inflammatory hue in the tissue will also detract from the final result.

Gingival inflammation tends to increase the deeper a crown margin is placed within the sulcus.[19,20] While controversy exists as to how far subgingivally a crown margin should end, 0.5 to 1.0 mm seems to be agreed upon, unless the tissue biotype is extremely thin.[4,19,21–23] Since gingival recession may occur as a result of trauma, tissue biotype, manipulation during crown preparation, root prominence, and ongoing passive eruption, it would seem desirable to place a crown margin in the esthetic zone as far intrasulcularly as is clinically acceptable.

Esthetic crown lengthening

A primary objective of contemporary dentistry is to optimize the results for patients desiring esthetic periodontal restorative treatment. While a myriad of restorative techniques are used to enhance the overall quality of the definitive restoration, obtaining a clinical crown length that remains stable and an understanding of the management of the interdental tissue, including the changes that occur in the papilla in response to alterations in tooth contour and contact position, are also imperative.

Fig 1 *Initial clinical appearance of the patient.*

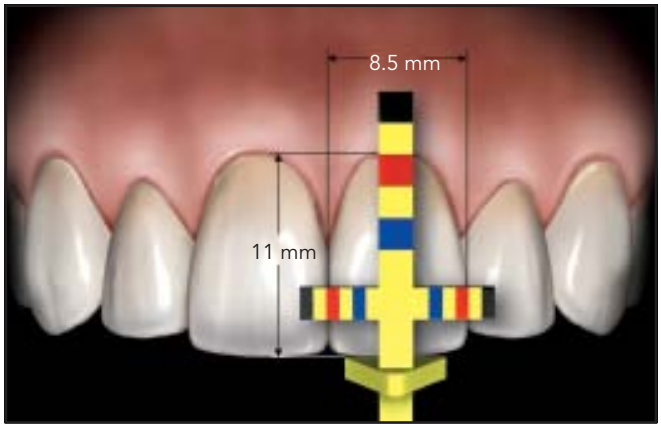
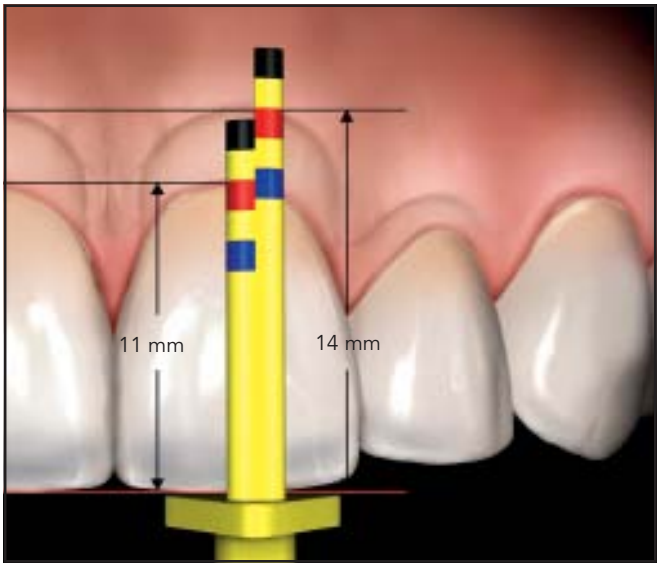


Fig 2a *T-Bar Proportion Gauge. The widths of the color markings on the horizontal arm are 75% to 80% of the lengths of the corresponding color markings on the vertical arm.*



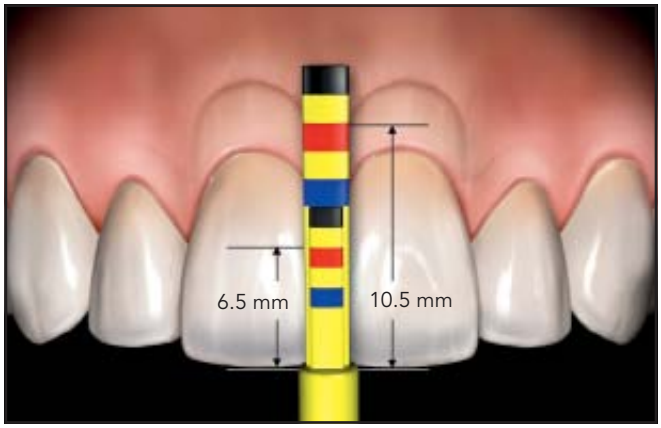


Fig 2b (left) *Crown lengthening gauge (Biologic Periogauge). The color markings on the longer arm are 3 mm greater than the same color markings on the shorter arm.*

Fig 2c (above) *Papilla Tip Gauge.*

Case report

A 29-year-old man was not pleased with the appearance of his smile and desired to modify the size and shape of his maxillary incisors (Fig 1). A comprehensive periodontal and restorative evaluation was performed. It was determined that periodontal esthetic crown lengthening surgery was indicated, followed by the esthetic restoration of the four maxillary incisors. Chu Aesthetic Gauges (Hu-Friedy) (Figs 2a to 2c) were used as guides in establishing the correct occlusogingival clinical dimension of the tooth as a function of its width and the correct papilla position as a function of its length. Additionally, the gauges determined the correct biologic length of each crown as a function of the clinical length.

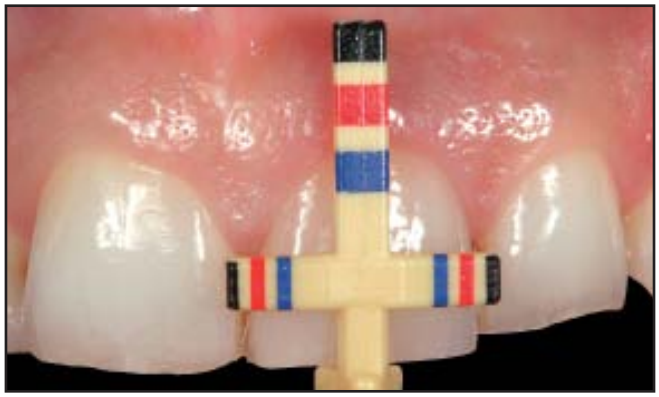


Fig 3 *Proportion Gauge in place. The tooth width is to the outer edge of the red markings on the horizontal arm. Therefore, the proportionate clinical crown length will be to the outer edge of the red markings on the vertical arm.*

Fig 4 *Biologic Periogauge tip replaced the Proportion Gauge after the desired clinical crown length was established midfacially by placing bleeding points.*

The desired incisal edge position of the teeth was established first based on esthetics and phonetics. It may involve shortening or adding bonding material to the incisal edge or full temporization. The incisal stop of the T-Bar Proportion Gauge was then placed on the incisal edge of the tooth (Fig 3). Since the ideal clinical crown length of an anterior tooth is a function of its width, the colored markings on the horizontal (width) bar of the Proportion Gauge correspond proportionally to the colored markings on the vertical (crown length) bar. The crown-lengthening gauge, Biologic Periogauge (Fig 2b), is a dual-armed instrument. The shorter clinical crown length arm corresponds exactly to the length of the vertical arm of the Proportion Gauge, and the longer arm is the biologic crown length arm. The colored markings on this arm are 3 mm longer than the corresponding markings on the shorter arm and indicate where the bone crest should be midfacially relative to the gingival margin. This additional 3 mm provides adequate tooth structure for the biologic width as well as for the placement of an intracrevicular crown margin. Figure 3 shows the width of the left central incisor to be 8.5 mm (outer edge of red markings). The corresponding outer edge of the red markings on the vertical bar is 11 mm. This yields a width-to-length percentage of 77%, which is within the ideal 75% to 80%.[24,25]

Bleeding points were established at the zenith of the desired clinical crown length, as determined by the Proportion Gauge. The Biologic Periogauge tip replaced the Proportion Gauge tip (Fig 4). Since adequate keratinized gingiva was present in this example, a gingivectomy was performed to the desired color markings on the short arm of the Biologic Periogauge (Fig 5). A sulcular incision was made, and the labial gingiva was reflected, keeping the palatal half of the interproximal papilla intact (Figs 6 and 7a). Once the clinical crown length was established, the bone was recontoured in a parabolic fashion with the osseous scallop paralleling the cementoenamel junction circumferentially.[23] The bone was recontoured on the direct facial to the appropriate marking on the long arm and around the line angles to provide 3 mm of tooth structure for the placement of a restorative margin and the reestablishment of the biologic width (Figs 7a and 7b).

The interproximal papilla will reform if the distance from the base of the contact area to the crest of bone is 5 mm or less.[26] Papilla reformation is also a function of the width

Fig 5 *Appearance of the teeth following gingivectomy to the desired clinical crown length. Note: The length of the papilla is now disproportionately long in relation to the length of the clinical crown.*

Fig 6 *The labial gingiva was reflected; the palatal half of the interproximal papilla remained intact.*

Fig 7a *Gingiva reflected with the Biologic Periogauge in place. The top of the red mark on the shorter arm is the desired clinical crown length; the top of the red mark on longer arm is the desired osseous level for a proper biologic crown length. Note the position of bone and connective tissue at the line angles of the teeth.*

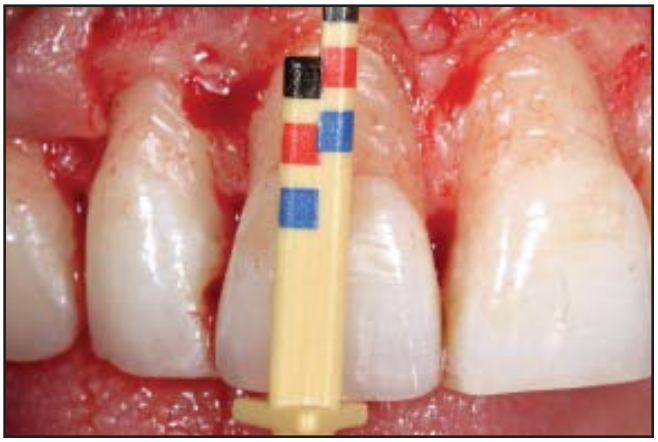


Fig 7b *Position of bone following crown lengthening. Note the recontouring of bone toward the palate around the line angles and interproximally.*

between the roots of teeth, and if the roots are greater than 2.4 mm apart, papilla reformation tends to decrease when bone is absent.[27,28]

Interproximal bone was recontoured judiciously to minimize the chances of losing the papilla. It was ramped and festooned from the labial to the palatal aspect to expose adequate tooth structure around the labial line angles (Fig 7b). Depending on how far palatally the bone must be recontoured, the interproximal gingiva is carefully thinned toward the palate with a fine diamond. The palatal bone should be removed incrementally, and the exposed tooth structure should be thoroughly root planed to minimize the possibility of reattachment of residual connective tissue fibers.[16,17]

Fig 8 *The flap was sutured and the clinical crown was at its desired length. The length of papilla was now proportionate to the crown length.*

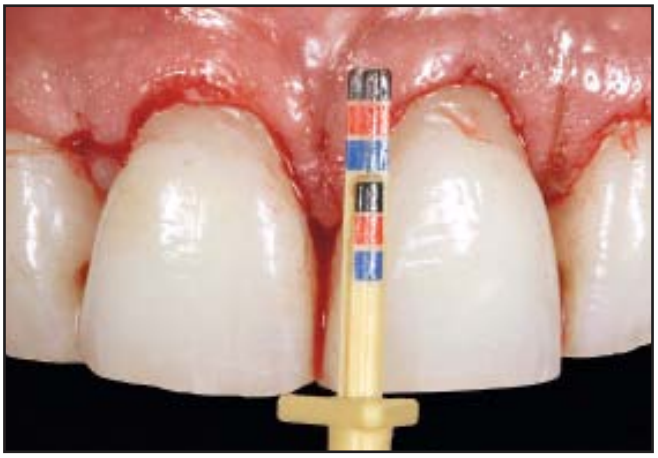


Fig 9 *The papilla tip is at the top of the red mark on short arm, which places it at 40% of the length of the clinical crown.*

Fig 10 *Clinical appearance 8 weeks postsurgery.*

The extent to which the interproximal bone is thinned palatally, whether the inner aspect of the labial papilla is thinned, whether the coronal tip of the palatal papilla is removed, and whether the bone is removed horizontally are all factors that will determine the final position of the labial papilla. When visualized three-dimensionally, modifying one or more of these factors will lead to a more apical positioning of the papilla (Fig 8). Interproximal bone should be removed horizontally only when the other options prove to be inadequate. If the palatal wall of bone must be reduced to position the papilla apically or to expose additional tooth structure for crown lengthening, the palatal flap should be reflected minimally and gently and should include the remaining tissue of the attachment apparatus.

The color codes on the longer arm of the Papilla Tip Gauge measure the height of the interproximal bone crest to the incisal edge, and the corresponding color codes on the shorter papilla arm are 4 mm more coronal. By placing the Papilla Tip Gauge interproximally, the surgeon can visualize where the papilla should end in relation to the interpoximal bone crest (Fig 9), and the restorative dentist and laboratory technician can use it to determine the position of the contact area in relation to the length of

Fig 11a *Definitive restorations in place.*

Fig 11b *There was no coronal migration of the gingiva on the direct facial aspect.*

Fig 11c *The papilla now ends at the top of the blue line on the papilla gauge, and the interproximal gingiva migrated coronally to fill the embrasure space.*

the clinical crown. Since the length of the papilla has been found to be approximately 40% to 50% of the length of the tooth,[29] the papilla should only be shortened 0.4 to 0.5 mm for every 1.0 mm that it is disproportionate to the length of the clinical crown to maintain the proper crown-papilla ratio.

Healing was rapid and uneventful (Fig 10), and the dentogingival complex consisted of a gingival sulcus, junctional epithelium, and connective tissue fiber barrier populating the apical 3 mm of supraosseous tooth structure. While osseous remodeling continues histologically for longer than 12 months, soft tissue healing is mostly completed after 8 weeks.[30] What must be assessed at this point is the maturation of the gingiva and the stability of the position of the gingival margin. If the gingival contour has stabilized and a crown margin is atraumatically placed intracrevicularly, the definitive restorations can be placed successfully within 8 to 12 weeks.[31] The restorative dentist should have more than adequate tooth structure for the placement of an intracrevicular crown margin, there should be minimal coronal migration of the buccal gingiva, and the papilla should fill the embrasure space (Fig 11).

Discussion

Crestal bone must often be removed when performing esthetic crown lengthening to provide adequate tooth structure for the establishment of an attachment apparatus and the placement of an intracrevicular crown margin. Since acrylic templates are often imprecise[32] and it has been shown that less than 3 mm of tooth structure is routinely removed during crown lengthening procedures,[33] an objective measuring device would be a valuable aid in assuring sufficient tooth structure is exposed, as well as in establishing a clinical crown with an ideal width-to-length proportional relationship.[34]

Clinicians will, on occasion, attempt to construct a crown with less than 3 mm of available subgingival tooth structure, resulting in the crown margin being placed within the connective tissue attachment or at the bone crest. Theoretically, sufficient horizontal bone resorption will subsequently occur for a more apical establishment of the attachment apparatus. While resorption of this type often occurs on the direct buccal aspect, where the buccal plate of bone tends to be thin, it is less predictable at the line angles and interproximally. It is here, where the roots are relatively far apart, that the bone thickens as it contours into the embrasures and vertical troughing can occur because of inadequate crestal resorption. The crown margin subsequently becomes a chronic irritant, and the characteristic inflammatory appearance of biologic width impingement occurs.

Similarly, a gingivectomy to establish a desired clinical crown length, followed by thorough root planing without flap elevation, may remove all supracrestal fibers and stimulate adequate crestal resorption for the successful placement of a subgingival crown margin. Coronal gingival rebound and biologic width problems tend to be more frequent occurrences, though, and experience has shown the stability of the definitive restoration to be less predictable than when the gingiva is flapped and osseous recontouring performed.[31,35,36]

A minimum of 2 to 5 mm of keratinized tissue is required for gingival health.[37,38] In the highlighted case, where the patient had a healthy, fibrous biotype and laminate veneers were being placed, it was felt that a minimum of 2 to 3 mm of keratinized tissue would be adequate for gingival health. A gingivectomy was subsequently performed to expose the needed additional tooth structure as opposed to using an intrasulcular incision to reposition the tissue apically.

While the amount of bone that must be removed to provide appropriate biologic crown length may, on occasion, appear visually striking, tooth mobility does not become an issue when adequate bone is present originally. When bone levels are compromised initially and recession has not occurred, apical positioning of the buccal gingiva or a gingivectomy may be adequate to achieve the desired result.

Management of the papilla is an important aspect of esthetic

crown lengthening. As shown in the present case, the interproximal tissue will proliferate coronally and the papilla will reform as long as the distance from the bone crest to the base of the contact area is 5 mm or less[12,26] and the interradicular distance between the teeth is 2.4 mm or less (Fig 11c).[27,28] Any minor residual interproximal spacing that may remain can be eliminated by positioning the contact area of the definitive restoration further apically.

Conclusions

The esthetic restorative process requires the participation of both the periodontist and restorative dentist. Proper modification of the height and contour of the gingiva, as well as the length of the clinical and biologic crown, is intrinsic in obtaining an optimal final result. The dynamics of hard and soft tissue wound healing are topics the periodontist is intimately familiar with. A technique for crown lengthening was presented that uses a unique set of measuring devices to objectively define the ideal clinical length of an anterior tooth as a function of its width. The gauges then provide the surgeon with a guide that determines precisely how much bone must be removed from a biologic standpoint to ultimately produce a restoration of the highest clinical quality. Perhaps, most importantly, periodontal esthetic restorative therapy and the gauges foster a collaborative interaction between the periodontist and restorative dentist. It is this ongoing communication directed toward a jointly achieved, successful, final result that is the foundation of a mutually rewarding, long-term, working relationship.

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