

Biologic Width

Yeh S, Andreana S. Crown lengthening: basic principles, indications, techniques and clinical case reports. N Y State Dent J. 2004 Nov;70(8):30-6.

Sometimes, in order to properly restore teeth, surgical intervention in the form of a crown-lengthening procedure is required. Crown lengthening is a periodontal resective procedure, aimed at removing supporting periodontal structures to gain sound tooth structure above the alveolar crest level. Periodontal health is of paramount importance for all teeth, both sound and restored. For the restorative dentist to utilize crown lengthening, it is important to understand the concept of biologic width, indications, techniques and other principles. This article reviews these basic concepts of clinical crown lengthening and presents four clinical cases utilizing crown lengthening as an integral part of treatments, to restore teeth and their surrounding tissues to health.

Alpiste-Illueca F. Dimensions of the dentogingival unit in maxillary anterior teeth: a new exploration technique (parallel profile radiograph). Int J Periodontics Restorative Dent. 2004 Aug;24(4):386-96.

This study sought to develop and evaluate a radiographic exploration technique (parallel profile radiograph [PPRx]) for measuring the dentogingival unit on the buccal surfaces of anterior teeth, and to provide additional information on the dimensions of the dentogingival unit in humans. In 88 periodontally healthy individuals, a PPRx was made of the maxillary left central incisor. Over these images, the components of the dentogingival unit were measured. PPRx was a highly reproducible exploratory technique. Mean dentogingival measurements on the buccal surfaces of the teeth were 2.05 +/- 0.87 mm for distance between the CEJ and bone crest; 2.00 +/- 0.72 mm for biologic width; 1.75 +/- 0.24 mm for thickness of connective tissue attachment; 1.12 +/- 0.24 mm for thickness of free gingiva at its base; 0.45 +/- 0.20 mm for thickness of bone plate at crest level; and 1.41 +/- 0.62 mm for gingival overlap on enamel surface. A statistically significant relationship was observed between free gingival width and thickness of connective attachment, and the depth of the gingival sulcus. These results corroborate the notion that the dimensions of the dentogingival unit are highly variable in humans. The thicknesses of both the connective tissue attachment and free gingiva, however, showed less variability than did the thickness of the bone crest, distance between CEJ and bone crest, and biologic width. The results suggest that gingival dimensions are correlated to dentogingival unit dimensions.

Gallucci GO, Belser UC, Bernard JP, Magne P. Modeling and characterization of the CEJ for optimization of esthetic implant design. Int J Periodontics Restorative Dent. 2004 Feb;24(1):19-29.

This study evaluated the dimensions and characteristics of the cemento-enamel junction (CEJ) of maxillary anterior teeth; the natural CEJ was compared to current implant design and used for design optimization. Standardized digital images of 137 extracted human teeth (45 central incisors, 46 lateral incisors, and 46 canines) were used to measure cervical dimensions, CEJ curvature, and distance from zenith of CEJ to interdental contact on proximal views. The x- and y-coordinates of the CEJ contour were digitized before mathematic processing to allow the representation of a single average curve for buccal, palatal, mesial, and distal surfaces for each tooth type. These measurements were combined to existing data related to dentogingival and "implantomucosal" junction to extrapolate specific biologic landmarks around teeth and implants. Mean cervical dimensions, distance from zenith of CEJ to interdental contact, and CEJ curvature were compared. Cervical dimensions significantly differed, with a more symmetric cervical cross-section for central incisors, slightly more rectangular shape for lateral incisors, and distinctly rectangular shape for canines. CEJ curvature was statistically different between all tooth groups (centrals > laterals > canines); within groups, curvature value was always superior at the mesial aspect compared to distally (3.46 mm vs 3.13 mm for centrals, 2.97 mm vs 2.38 mm for laterals, and 2.55 mm vs 1.60 mm for canines). Tooth-implant biologic width discrepancies ranged from 4.10 to 5.96 mm and were different between all groups of teeth (centrals > laterals > canines); within groups, the discrepancy was always superior at the mesial aspect compared to distally. Current implant design featuring a flat, rotation-symmetric shoulder should be reconsidered in view of natural CEJ contour to improve biologic considerations and related esthetics.

Felippe LA, Monteiro Junior S, Vieira LC, Araujo E. Reestablishing biologic width with forced eruption. Quintessence Int. 2003 Nov-Dec;34(10):733-8.

Maintenance of gingival health is one of the keys for the longevity of teeth, as well as for the longevity of restorations. In this context, the biologic width functions as a barrier against the entrance of microorganisms into the internal medium of the periodontal ligament and into the gingival and osseous connective tissue. This clinical case describes a technique to reestablish the biologic width of a central incisor using forced extrusion and done without post-treatment corrective surgery.

Padbury A Jr, Eber R, Wang HL. Interactions between the gingiva and the margin of restorations. J Clin Periodontol. 2003 May;30(5):379-85.

An adequate understanding of the relationship between periodontal tissues and restorative dentistry is paramount to ensure adequate form, function, esthetics, and comfort of the dentition. While most clinicians are aware of this important relationship, uncertainty remains regarding specific concepts such as the biologic width and indications and applications for surgical crown lengthening. This review discusses the concept of the biologic width and its relationship to periodontal health and restorative dentistry. The

importance of restorative margin location, materials, and contours related to periodontal health is also addressed. The rationale and indications for surgical crown lengthening are elaborated. Particular surgical principles of crown lengthening are examined in detail.

Nemcovsky CE, Artzi Z, Moses O. Preprosthetic clinical crown lengthening procedures in the anterior maxilla. Pract Proced Aesthet Dent. 2001 Sep;13(7):581-8; quiz 589.

Clinical crown lengthening procedures (CCLP) are used to enhance aesthetics and/or provide adequate tooth structure for placement and retention of a restoration while respecting the attachment apparatus. When restoration margins extend beyond the biologic width, inflammation and anatomic changes can develop. Anterior CCLP are indicated to increase the labial exposure of the clinical crown and/or the sound tooth structure coronal to the bone crest. Preservation of the interproximal papillae is mandatory to obtain desirable final results in the aesthetic region. This article illustrates various methods of CCLP used to achieve successful oral rehabilitation in the anterior maxilla.

Melker DJ, Richardson CR. Root reshaping: an integral component of periodontal surgery. Int J Periodontics Restorative Dent. 2001 Jun;21(3):296-304.

It is the aim of this article to present a surgical option to the traditional method of returning lost biologic width where invasion of the junctional and/or connective tissue attachment associated with a tooth has occurred. The alternative to conventional osseous resection involves reshaping the existing tooth surface in combination with conservative removal of the supporting alveolar bone to create the width needed for the restoration to be biologically acceptable. This procedure accomplishes several goals: (1) minimum supporting bone is removed; (2) deleterious root surface anatomy, such as grooves, concavities, and cemento-enamel projections, is diminished; (3) a smooth root surface that is more biologically acceptable to soft tissue is created; (4) Class I and II furcation lesions may be decreased or eliminated; and (5) improved gingival contours and space for restorative materials can be created in situations in which close root proximity is present. This article will present a step-by-step approach to using root reshaping as an alternative to traditional crown lengthening.

Valerio S, Crescini A, Pizzi S. Hard and soft tissue management for the restoration of traumatized anterior teeth. Pract Periodontics Aesthet Dent. 2000 Mar;12(2):143-50; quiz 152.

The restoration of coronally fractured anterior teeth without surgical invasion is contingent upon several factors. Specifically, the biologic width of the tooth should not be violated by the apical extent of the fracture, and the residual root structure must

possess an adequate ferrule. In patients with these conditions, it is possible to prosthetically restore the tooth following orthodontic extrusion. This article describes a technique in which orthodontic extrusion is utilized to provide adequate tooth structure for the prosthetic restoration of patients who presented with fractured anterior teeth.

Gunay H, Seeger A, Tschernitschek H, Geurtsen W. Placement of the preparation line and periodontal health--a prospective 2-year clinical study. *Int J Periodontics Restorative Dent.* 2000 Apr;20(2):171-81.

The aim of this prospective clinical 2-year study was to determine whether the placement of the proximal margins of crowns within the zone of the biologic width results in periodontal alterations. In 41 patients, 116 prepared teeth as well as 82 unrestored, healthy contralateral teeth were examined. The following indices were determined before as well as 3, 6, 12, and 24 months after preparation: hygiene index, papillary bleeding index (PBI), and probing depth. After preparation, the distance between the restoration margins and the alveolar crest was measured with a modified periodontal probe on both proximal aspects of each tooth. These values were classified into 3 groups: I = < or = 1 mm between crown margin and alveolar crest, II = 1 to 2 mm, and III = > 2 mm. In addition, radiographs were taken directly after cementation of each restoration and after 12 and 24 months. The hygiene index did not significantly vary during the investigation, but PBI increased in all groups. The highest PBI increase was found in group I; in this group, the most significant increase was found between 3 and 6 months after preparation. The mean probing depth only increased in group I during the first 3 months after preparation on the mesial aspects. Only minor changes were found on the distal aspects of the teeth in group I and on all aspects in groups II and III. No alterations of the bone levels were diagnosed on the radiographs. These results indicate that the location of the restoration margins within the zone of the biologic width may impair the periodontal health of restored teeth.

Frank CA, Pearson BS, Booker BW. Orthodontic eruption of furca-involved molars. *Compend Contin Educ Dent.* 1995 Jul;16(7):664, 666, 668 passim; quiz 682.

Guided tissue regeneration techniques, which are used in the treatment of certain advanced Class II and Class III furca-involved teeth, have progressed from promising to predictable. However, furca-modification techniques remain important aspects of treatment. Tooth eruption, combined with standard furca-modification techniques, improves the prognosis for both the treated and the adjacent teeth. Continued eruption of periodontally involved molars improves the crown-to-root ratio and maintains the periodontium of the adjacent dentition. These same concepts can be used to treat restoratively compromised molars, many of which were considered hopeless and subsequently extracted. Passive eruption can be useful in treating cases that need less than 3 mm of tooth eruption; orthodontic-active eruption with fixed appliances is advised if more than 3 mm of eruption is desired. Slower eruption rates (2 mm per month) allow the periodontal ligament to repair and the alveolar bone to remodel between orthodontic

adjustments (3 to 4 weeks between adjustments). Periodic periodontal maintenance is accomplished during orthodontic treatment. After a retention period (8 weeks), periodontal surgery should be performed to reestablish the tooth's biologic width. After surgical wound healing (6 to 8 weeks), the tooth should be restored.

Assif D, Pilo R, Marshak B. Restoring teeth following crown lengthening procedures. J Prosthet Dent. 1991 Jan;65(1):62-4.

Crown lengthening procedures are often necessary to successfully restore teeth that have been mutilated at or below the level of the bone crest. Forced eruption is preferred to surgical removal of supporting alveolar bone, since forced eruption preserves the biologic width, maintains esthetics, and at the same time exposes sound tooth structure for the placement of restorative margins. To properly construct a crown, the minimal distance from the alveolar crest to the coronal extent of sound tooth structure should be 4 mm. Before initiation of forced eruption, the restorability of the root after completion of the orthodontic phase must be considered. A technique is suggested to calculate the root-to-crown ratio that will be created after root extrusion with respect to the coronal level of sound tooth structure before treatment.

Reeves WG. Restorative margin placement and periodontal health. J Prosthet Dent. 1991 Dec;66(6):733-6.

Subgingival restorative margins are associated with the development of plaque-related inflammatory periodontal disease, primarily because of a shift in the subgingival microflora from a profile associated with health to one associated with disease. The degree and extent of the marginal inflammation is influenced by four factors: failure to maintain proper emergence profile, inability to adequately finish and/or close subgingival margins, placement of subgingival margins in an area with minimum to no attached gingiva, and violation of the biologic width. Supragingival margin placement is the location of choice for all restorative margins to avoid iatrogenic periodontal disease. However, consideration of these four factors will help reduce the adverse impact of restorative margins that must be carried subgingivally.

IMPLANT IMPLICATIONS:

Hartman GA, Cochran DL. Initial implant position determines the magnitude of crestal bone remodeling. J Periodontol. 2004 Apr;75(4):572-7.

BACKGROUND: The ability to predict the amount of bone remodeling around implants is important for a stable and predictable esthetic result. The purpose of this study was to investigate the amount of radiographic bone remodeling that occurs over time using a

one-piece implant system. **METHODS:** Twenty-seven patients receiving implants in the maxilla and 15 receiving implants in the mandible were included in the study. All implants were placed with a non-submerged surgical technique with varying locations of the rough-smooth border with respect to the alveolar crest. Clinical exams and radiographs were taken on the day of implant placement, at 6 months, and annually up to 5 years. Linear measurements from digitized radiographs were made from the implant shoulder to the first bone-to-implant contact at all time points. **RESULTS:** A significant amount of bone remodeling compared to baseline occurred for all implants at the 6-month follow-up visit (1.10 mm), with the remaining time points showing virtually no change (0.1 mm). A relationship was found between the amount of bone remodeling and the location of the rough-smooth border with respect to the alveolar crest. Those implants with the rough-smooth border surgically placed below the crest had, on average, a greater amount of remodeling at 6 months (average 1.72 mm) than implants with the rough-smooth border placed at or near the crest (average 0.68 mm). In both situations, this remodeling: 1) occurred early (within 6 months), 2) reached a similar level, and 3) remained virtually unchanged up through 60 months (0.05 mm). **CONCLUSIONS:** A physiologic dimension appears to exist between the bone and the implant-crown interface around one-piece implants that is established early and maintained over time. These results are significant because they demonstrate in patients that the magnitude of initial bone remodeling around these one-piece dental implants is dependent on the positioning of the rough-smooth border of the implant in an apico-coronal dimension. Furthermore, the dimension, from the crown-implant interface to the first bone-to-implant contact, is consistent with the formation of a biologic width similar to that found around the natural dentition.

Joly JC, de Lima AF, da Silva RC. Clinical and radiographic evaluation of soft and hard tissue changes around implants: a pilot study. J Periodontol. 2003 Aug;74(8):1097-103.

BACKGROUND: The aim of this study was to evaluate the clinical and radiographic changes in the peri-implant tissues around one-stage implants with different smooth neck portion lengths before and after functional prosthetic loading. **METHODS:** Twelve one-stage implants were placed in adult patients with bilateral edentulous posterior mandibular ridges. The sites were randomly assigned into two groups of six each: group 1: 2.8 mm neck implants and group 2: neck implants. The parameters plaque index (PI), gingival index (GI), probing depth (PD), gingival margin level (GML), relative clinical attachment level (r-CAL), and optical density (OD) were measured at loading (4 months) and 12 months after implant placement. The radiographic parameter osseous level (OL) was measured at implant placement, loading, and at 12 months. Analysis of variance and the paired Student t test were used to detect difference over time and between groups. **RESULTS:** The results showed significant differences ($P < 0.05$) for both groups for PD, r-CAL, and OL for intragroup comparisons over time. However, no significant differences were found for PI, GI, PD, GML, OD, and OL for between-group comparisons. **CONCLUSION:** Bony loss occurred before loading, supporting the soft tissues and maintaining the biologic width irrespective of the smooth portion length.

Hermann JS, Buser D, Schenk RK, Schoolfield JD, Cochran DL. Biologic Width around one- and two-piece titanium implants. Clin Oral Implants Res. 2001 Dec;12(6):559-71.

Gingival esthetics around natural teeth is based upon a constant vertical dimension of healthy periodontal soft tissues, the Biologic Width. When placing endosseous implants, however, several factors influence periimplant soft and crestal hard tissue reactions, which are not well understood as of today. Therefore, the purpose of this study was to histometrically examine periimplant soft tissue dimensions dependent on varying locations of a rough/smooth implant border in one-piece implants or a microgap (interface) in two-piece implants in relation to the crest of the bone, with two-piece implants being placed according to either a submerged or a nonsubmerged technique. Thus, 59 implants were placed in edentulous mandibular areas of five foxhounds in a side-by-side comparison. At the time of sacrifice, six months after implant placement, the Biologic Width dimension for one-piece implants, with the rough/smooth border located at the bone crest level, was significantly smaller ($P < 0.05$) compared to two-piece implants with a microgap (interface) located at or below the crest of the bone. In addition, for one-piece implants, the tip of the gingival margin (GM) was located significantly more coronally ($P < 0.005$) compared to two-piece implants. These findings, as evaluated by nondecalcified histology under unloaded conditions in the canine mandible, suggest that the gingival margin (GM) is located more coronally and Biologic Width (BW) dimensions are more similar to natural teeth around one-piece nonsubmerged implants compared to either two-piece nonsubmerged or two-piece submerged implants.

Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol. 2000 Apr;71(4):546-9.

BACKGROUND: The biologic width around implants has been well documented in the literature. Once an implant is uncovered, vertical bone loss of 1.5 to 2 mm is evidenced apical to the newly established implant-abutment interface. The purpose of this study was to evaluate the lateral dimension of the bone loss at the implant-abutment interface and to determine if this lateral dimension has an effect on the height of the crest of bone between adjacent implants separated by different distances. **METHODS:** Radiographic measurements were taken in 36 patients who had 2 adjacent implants present. Lateral bone loss was measured from the crest of bone to the implant surface. In addition, the crestal bone loss was also measured from a line drawn between the tops of the adjacent implants. The data were divided into 2 groups, based on the inter-implant distance at the implant shoulder. **RESULTS:** The results demonstrated that the lateral bone loss was 1.34 mm from the mesial implant shoulder and 1.40 mm from the distal implant shoulder between the adjacent implants. In addition, the crestal bone loss for implants with a greater than 3 mm distance between them was 0.45 mm, while the implants that had a distance of 3 mm or less between them had a crestal bone loss of 1.04 mm. **CONCLUSIONS:** This study demonstrates that there is a lateral component to the bone

loss around implants in addition to the more commonly discussed vertical component. The clinical significance of this phenomenon is that the increased crestal bone loss would result in an increase in the distance between the base of the contact point of the adjacent crowns and the crest of bone. This could determine whether the papilla was present or absent between 2 implants as has previously been reported between 2 teeth. Selective utilization of implants with a smaller diameter at the implant-abutment interface may be beneficial when multiple implants are to be placed in the esthetic zone so that a minimum of 3 mm of bone can be retained between them at the implant-abutment level.

Animal Implants

Siar CH, Toh CG, Romanos G, Swaminathan D, Ong AH, Yaacob H, Nentwig GH. Peri-implant soft tissue integration of immediately loaded implants in the posterior macaque mandible: a histomorphometric study. J Periodontol. 2003 May;74(5):571-8.

BACKGROUND: Today, one critical goal in implant placement is the achievement of optimal soft tissue integration. Reports thus far have demonstrated successful soft tissue preservation in delayed loaded implants placed in anterior jaws. The aim of this study was to histomorphometrically examine the soft tissues around immediately loaded implants placed in the macaque posterior mandible. **METHODS:** Splinted crowns on screw-shaped titanium implants (8 mm length, 3.5 mm diameter) were utilized. Three implants each were placed in the premolar-molar edentulous mandibular segments of 6 adult monkeys (*Macaca fascicularis*); one side served as the control (delayed loading) and the other as the test sites (immediate loading). The animals were sacrificed after 3 months of loading. Histomorphometry of 6 soft tissue indices including the sulcus depth (SD), junctional epithelium (JE), connective tissue contact (CTC), biologic width (BW = SD + JE + CTC), DIM (distance between the implant top and coronal gingiva), and DIB (distance between the implant top and first implant-to-bone contact) was performed on non-decalcified sections. **RESULTS:** No significant differences in the mean soft tissue scores (mm) between the test (SD = 0.68 +/- 0.63; JE = 1.71 +/- 1.04; CTC = 1.51 +/- 1.14; DIM = 2.27 +/- 1.18; DIB = 1.32 +/- 1.21; BW = 3.9) and control (SD = 0.88 + 0.57; JE = 1.66 + 0.77; CTC = 1.24 +/- 0.92; DIM = 2.38 +/- 0.81; DIB = 1.19 +/- 0.91; BW = 3.78) groups were observed ($P > 0.01$). **CONCLUSION:** These findings suggest that the dimensions of the peri-implant soft tissues were within the biologic range and were not influenced by immediate functional loading or posterior location of the implants in the macaque mandible.