Evaluation of Supracrestal Gingival Tissue After Surgical Crown Lengthening: A 6-Month Clinical Study

Ritika Arora,* Satish C. Narula,* Rajinder K. Sharma,* and Shikha Tewari*

Background: Previous studies on crown lengthening (CL) report contradictory results regarding stability of crown length gained at the time of surgery. The "3-mm rule" has dictated the amount of alveolar bone to be removed during CL surgery for decades. With the current understanding of wide variations in supracrestal gingival tissue (SGT) dimensions, bone removal can be customized to the situation. The purpose of this study is to assess alterations in periodontal tissue levels 6 months after CL surgery and to evaluate factors that may influence stability of CL achieved over time.

Methods: Sixty-four patients requiring CL surgery on 64 teeth are included in this study. Clinical parameters were recorded along six surfaces of treated tooth and neighboring teeth. Sites were labeled as treated sites, adjacent sites, and non-adjacent sites. Bone was reduced based on the minimal amount of tooth structure required for restorative purpose and SGT dimensions at each site. Patients were re-evaluated at 3 and 6 months.

Results: Significant soft-tissue rebound (0.77 ± 0.58 mm) was observed 6 months after CL surgery. This rebound was found to be significantly correlated with periodontal biotype (r = 0.325, P = 0.000) and post-suturing flap position (r = –0.601, P = 0.000). SGT was not reestablished to its preoperative dimensions by the end of 6 months (P = 0.001).

Conclusions: Crown length gained during surgery significantly decreased 6 months post-surgery. Suturing the flap ≤3 mm from the osseous crest and thick-flat biotype were associated with greater tissue rebound. *J Periodontol 2013;84:934-940.*

KEY WORDS

Bone; crown lengthening; gingiva; stents; surgery; surgical flaps.

* Department of Periodontics and Oral Implantology, Post Graduate Institute of Dental Sciences, Rohtak, Haryana, India.

Periodontal health is one of the prerequisites for the success of a restorative procedure. Supragingival placement of restorative margins is generally preferred because it facilitates impression making, finishing of the restoration, verification of its marginal integrity, and maintenance of gingival health.[1-3] However, certain clinical situations require placing the restoration margins deep subgingivally, resulting in a periodontal lesion characterized by gingival inflammation, attachment loss (AL), and alveolar bone resorption with the violation of an entity called biologic width.[4-9] The concept of biologic width stems from the classic histologic study by Gargiulo et al.[10] and later by Vacek et al.,[11] with its average dimensions being reported to be nearly 2 mm. Based on results of these studies, various authors[12-14] have proposed a range of values (3 to more than 5 mm) for the amount of tooth structure to be exposed during crown lengthening. However, considering the significant variations in dimensions, the commonly used 3-mm rule[6,12] based on the 2-mm biologic width precept can be misleading if used empirically in the treatment of all cases. Lanning et al.,[15] in a study considering individual biologic width measurements for osseous resection, reported stability in gingival margin 3 months after crown-lengthening surgery.

Some authors[16,17] were of the opinion that working with the total dentogingival

doi: 10.1902/jop.2012.120162

complex rather than its individual components could eliminate the inherent errors in locating the base of the sulcus, suggesting the concept of supracrestal gingival tissue (SGT) that could dictate the amount of osseous resection required during crown lengthening. In the light of these views, a recent study[18] evaluated the individual SGT dimensions while performing crown-lengthening surgery and observed a difference in dimensions established 6 months post-surgery.

There is some consensus among studies regarding the post-surgical changes after crown-lengthening surgery.[15,18-23] Factors, such as patient's age and sex, periodontal biotype (PB), tooth type, post-surgical flap position, amount of bone reduction, surgical technique, and healing time, may influence the healing process and should be considered while estimating SGT dimensions for crown-lengthening surgery. A necessity for additional research stems from the perusal of the available literature, which reveals only some published studies wherein these factors have been taken into consideration,[19,20] with none of them having evaluated all of these together. Such exploration may eventually prove useful in formulation of specific guidelines for this procedure.

The present study is designed to assess alterations in the periodontal tissue levels after surgical crown lengthening over a 6-month healing period. It also aims to evaluate the factors that may govern the stability of crown height gained during crown-lengthening surgery over time and to find out whether the SGT for a particular tooth reformed after surgery approximates its preoperative dimensions.

MATERIALS AND METHODS

Study Population

This prospective clinical study was conducted at the Department of Periodontics and Oral Implantology, Post Graduate Institute of Dental Sciences, Rohtak, Haryana, India, from March 2010 to July 2011. The study sample consisted of 64 systemically healthy patients (38 males and 26 females, aged 18 to 63 years; mean age: 34.5 years) selected from those referred to the Department of Periodontics for crown-lengthening surgery. The inclusion criteria were: 1) aged ≥18 years; 2) plaque index (PI)[24] <1; 3) gingival index (GI)[25] <1; 4) absence of clinically significant systemic disease; 5) absence of any condition necessitating antibiotic prophylaxis; 6) not undergoing active orthodontic therapy; 7) absence of AL or history of periodontitis; and 8) absence of pathologic tooth mobility or furcation involvement. Exclusion criteria included: 1) patients who presented with any kind of contraindication to periodontal surgery; 2) patients teeth requiring crown lengthening with adjacent teeth missing; 3) pregnant and lactating females; and 4) smokers. The main indication for crown lengthening included an insufficient tooth structure coronal to the gingival margin resulting from extensive caries or tooth fracture. The study protocol was approved by the Postgraduate Board of Studies, Specialty of Periodontics, Pandit B.D. Sharma University of Health Sciences, Haryana, India, and was performed in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki, as revised in 2000. All patients were fully informed of the investigation and signed informed consent before examination.

A total of 192 teeth were included in the study, of which 64 teeth required crown lengthening and 128 teeth shared a proximal surface with the experimental teeth.

After an initial examination and treatment planning session, each patient received detailed instructions in proper self-performed plaque control measures and underwent scaling of teeth, if deemed necessary. Alginate impressions were made to provide study casts for the fabrication of customized probing stents. Full-arch probing stents were made from a 2-mm-thick clear copolyester plastic† using a pressure-form matrix machine.‡

Baseline Clinical Parameters

The following parameters were recorded at baseline: 1) PI according to Silness and Löe;[24] 2) GI according to Löe and Silness;[25] 3) width of keratinized gingiva; 4) PB recorded as thick-flat and thin-scalloped type based on visibility of periodontal probe through the gingival margin by a single calibrated examiner (RA)[26] (visible = thin; not visible = thick) 5) bleeding on probing (BOP) (present = 1; absent = 0); reference stent to the free gingival margin (FGM); 6) reference stent to the base of pocket described as relative attachment level (RAL); 7) bone level via trans-sulcular probing (BL-TSP) from the reference stent under local anesthesia; 8) after flap reflection, direct bone level (DBL) before osseous resection was measured from the reference stent to the osseous crest; 9) DBL after osseous resection from reference stent to the osseous crest; 10) after suturing, the distance of FGM after suturing from the reference stent; 11) distance of the osseous crest from the FGM after suturing; 12) probing depth (PD) measured as PD = RAL – FGM; and 13) SGT measured as SGT = BL-TSP – FGM.

All measurements were made with a calibrated and standardized manual periodontal probe§ to the nearest 0.5 mm by a single examiner (RA). Calibration exercises were conducted on 10 patients

† Splint biocryl, Great Lakes Orthodontics, Tonawanda, NY.
‡ Biostar, Great Lakes Orthodontics.
§ CP-15 UNC SE, Hu-Friedy, Chicago IL.

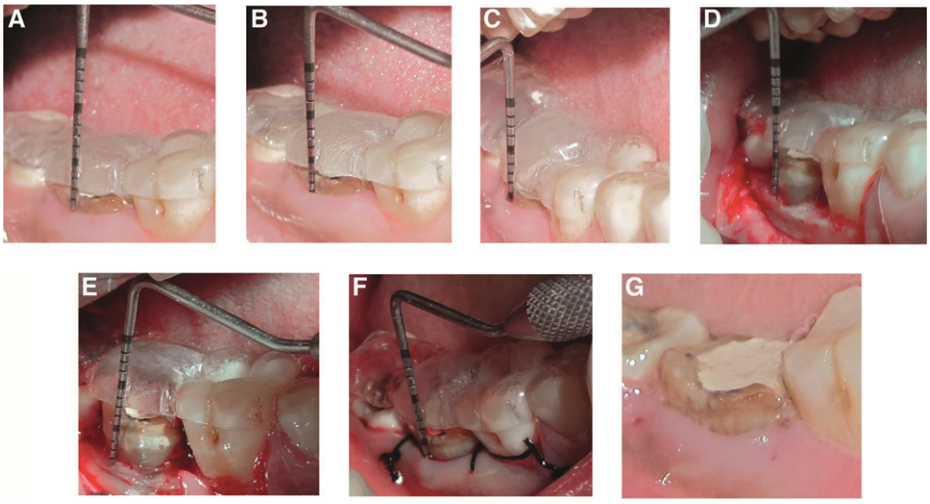

Figure 1.
Surgical procedure. ***A)*** *Preoperative image of tooth #31. Recording of FGM at baseline.* ***B)*** *Recording of RAL at baseline.* ***C)*** *Recording of bone level by TSP at baseline.* ***D)*** *After full-thickness flap reflection, recording of DBL.* ***E)*** *Recording of DBL after performing osseous resection.* ***F)*** *Recording of distance between FGM and osseous crest after suturing.* ***G)*** *Sutures removed 1 week after surgery.*

with two sets of readings taken in a 2-hour interval by a single examiner (RA). The assessment was made by an independent source, and intraexaminer reproducibility was found to be 90%. Measurements were made at six sites on the treated tooth and each adjacent tooth. The sites were labeled as treated (TT) (total of six sites on the treated tooth), adjacent (AA) (total of four sites on adjacent teeth that shared a proximal surface with the treated tooth), and non-adjacent (NA) (total of eight sites on the adjacent teeth away from the treated tooth). A total of 1,152 sites were included, of which 384 were TT sites, 256 were AA sites, and 512 were NA sites. The parameters PI, GI, BOP, FGM, RAL, and BL-TSP were recorded again at 3 and 6 months.

Surgical Procedure

After recording of measurements, incisions were planned based on the width of keratinized gingiva available. Intrasulcular and/or internal bevel incisions were then given, and full-thickness mucoperiosteal flaps were reflected on the buccal and lingual aspects to expose osseous and subgingival tooth structure. The osseous resection was determined by considering the amount of additional tooth structure required for restorative purpose and the preoperative SGT dimensions at each site. The needed osseous resection was performed with hand and rotary instruments under copious saline irrigation, keeping in mind positive bone architecture. After root planing, suturing of the surgical sites was done. The flap margins were placed at or apical to the anticipated crown margin after suturing. All surgical procedures and recording of parameters were performed by the same operator (RA), and necessary postoperative instructions were given. Patients were recalled after 1 week for suture removal and oral hygiene reinforcement. All patients were reevaluated at 3 and 6 months postoperatively. The surgical procedure is demonstrated in Figure 1.

Statistical analysis was performed using computer software.‖ Data obtained for each type of site per patient was averaged and assessed for differences between baseline, after surgery, 3 months, and 6 months. Data were analyzed by repeated-measures analysis of variance, followed by Tukey's post hoc test. Intraclass correlations were calculated to test for the reliability of TSP measurements versus DBL measurements, and the means were compared by *t* test. Partial correlation coefficients were calculated among factors, such as PB, tooth type, post-suturing flap position, amount of bone reduction performed, baseline SGT, and the amount of tissue rebound seen at the end of 6 months, controlling for age and sex. Those with significant correlations were then analyzed through linear regression model using enter method.

RESULTS

Of 64 patients requiring crown lengthening at the beginning of the study, 53 patients completed the study with a 6-month follow-up. No post-surgical complications were observed in any of the patients. A total of 11 patients could not complete the study (three patients relocated during the study period, and eight showed erratic compliance for the 6-month examination). Statistical analysis was performed for a total of 53 treated teeth and 106 adjacent teeth. The treated teeth included 19 incisors, 9 canines, 15 premolars, and 10 molars. No statistically significant difference was observed in PI, GI, or percentage BOP among TT sites, AA sites, and NA sites at any point of time. The mean AL at 3 months was observed to be 1.23, 1.08, and 0.32 mm for TT, AA, and NA sites, respectively. At the end of 6 months, this mean AL was observed to be 1.26, 1.10, and 0.35 mm for TT, AA, and NA sites,

‖ SPSS v.17.0, IBM, Chicago, IL.

Table 1.

Changes in Clinical Parameters for TT, AA, and NA Sites (mean ± SE)

Sites	FGM	RAL	PD	BL-TSP	SGT
TT (mm)					
Baseline to 3 months	1.87 ± 0.10	1.23 ± 0.12	–0.63 ± 0.11	1.17 ± 0.09	–0.69 ± 0.10
>3 to 6 months	0.14 ± 0.05	0.03 ± 0.07	0.17 ± 0.09	0.10 ± 0.03	0.24 ± 0.07
Baseline to 6 months	1.72 ± 0.11	1.26 ± 0.12	–0.45 ± 0.12	1.27 ± 0.10	–0.44 ± 0.12
AA (mm)					
Baseline to 3 months	1.51 ± 0.11	1.08 ± 0.11	–0.42 ± 0.11	0.99 ± 0.10	–0.51 ± 0.11
>3 to 6 months	0.09 ± 0.01	0.02 ± 0.06	0.11 ± 0.07	0.12 ± 0.05	0.21 ± 0.06
Baseline to 6 months	1.41 ± 0.12	1.10 ± 0.10	–0.31 ± 0.11	1.11 ± 0.08	–0.30 ± 0.12
NA (mm)					
Baseline to 3 months	0.79 ± 0.08	0.32 ± 0.07	–0.47 ± 0.08	0.14 ± 0.06	–0.65 ± 0.08
>3 to 6 months	0.07 ± 0.02	–0.03 ± 0.04	–0.10 ± 0.05	0.09 ± 0.02	0.16 ± 0.03
Baseline to 6 months	0.72 ± 0.08	0.35 ± 0.07	–0.36 ± 0.07	0.23 ± 0.06	–0.48 ± 0.08

Table 2.

Crown Lengthening Achieved at Different Time Periods (different levels of FGM as measured from reference stent) (mean ± SD)

Sites	Immediately After Surgery	3 Months	6 Months
TT (mm)	2.50 ± 0.72	1.87 ± 0.73*	1.72 ± 0.80*
AA (mm)	1.89 ± 0.83	1.51 ± 0.85*	1.41 ± 0.88*
NA (mm)	1.18 ± 0.73	0.79 ± 0.59*	0.72 ± 0.58*

* $P < 0.05$ from immediately after surgery

respectively. PD was found to significantly decrease at 3 and 6 months at all sites (Table 1).

Crown Lengthening Attempted Versus Achieved

The mean crown lengthening attempted during surgery at TT sites was 2.50 mm, but the crown lengthening achieved at the end of 6 months was 1.72 mm (Table 2). For AA and NA sites, the change in crown height was 1.89 and 1.18 mm, respectively, immediately after surgery and 1.41 and 0.72 mm, respectively, at the 6-month examination.

Bone Level

The mean distance of bone crest as measured from reference stent by TSP before flap reflection for TT, AA, and NA sites was 6.95, 6.70, and 6.92 mm, respectively. The mean values after flap reflection as measured from reference stent were 7.02, 6.77, and 6.95 mm, respectively, for TT, AA, and NA sites with no statistically significant difference between the two methods of measurement ($P = 0.000$) for all site types. Intraclass correlation coefficients for all types of sites measured by both TSP and DBL measurements ranged from 99.2% agreement for NA sites to 98.8% agreement for TT sites and 96.5% agreement for AA sites, showing a high degree of statistical significance ($P < 0.05$ for all coefficients). The amount of osseous resection ranged from 1 to 3 mm at 94% of TT sites. At treated teeth with a mean overall bone reduction of <1.50 mm, an average crown lengthening of 1.53 mm could be achieved, whereas bone reduction of ≥1.50 mm contributed toward a mean gain in crown length of 1.95 mm at the end of 6 months, with difference between the two groups being statistically non-significant ($P = 0.227$).

SGT Dimensions

At 6 months, baseline SGT dimensions of 3.50 ± 0.83, 3.73 ± 0.82, and 3.62 ± 0.64 mm for TT, AA, and NA sites, respectively, were significantly reduced to 3.05 ± 0.75, 3.43 ± 0.63, and 3.13 ± 0.48 mm ($P = 0.001$, $P = 0.049$, and $P = 0.000$).

Tissue Rebound After Surgery

The mean tissue rebound observed at 3 months was 0.63 ± 0.58, 0.38 ± 0.43, and 0.37 ± 0.45 mm for TT, AA, and NA sites, respectively. At the end of 6 months, it was found to be 0.77 ± 0.58, 0.47 ± 0.41, and 0.46 ± 0.53 mm, respectively. It

was seen that teeth with a thick-flat biotype experienced an overall mean tissue rebound of 0.70 ± 0.51 mm, which was significantly different from those with a thin-scalloped biotype, which was 0.37 ± 0.46 mm ($P = 0.000$).

The amount of tissue rebound was also found to vary with the distance between flap margin and osseous crest at the time of suturing, as depicted in Table 3.

The effect of tooth type on the amount of tissue rebound was analyzed by grouping the treated teeth into incisors, canines, premolars, and molars. The tissue rebound seen in anterior teeth was 0.56 ± 0.54 versus 0.64 ± 0.51 mm of rebound seen in the posterior teeth, with the difference being statistically non-significant ($P = 0.709$). The mean tissue rebound observed was 0.57 ± 0.52, 0.54 ± 0.47, 0.51 ± 0.53, and 0.79 ± 0.42 mm for incisors, canines, premolars, and molars, respectively, but the difference among groups ($P = 0.412$) and between any two groups was not statistically significant.

The partial correlation coefficient calculated among various factors and the amount of tissue rebound observed at 6 months came out to be statistically significant for post-suturing flap position ($r = –0.601$, $P = 0.000$) and PB ($r = 0.325$, $P = 0.000$). Linear regression analysis established an association of these two factors, with the amount of tissue rebound with the values for coefficients being $\beta = 0.216$ ($P = 0.001$) and $\beta = –0.563$ ($P = 0.000$) for PB and post-suturing flap position, respectively.

DISCUSSION

The results of the present clinical study demonstrate a progressive marginal soft-tissue rebound 6 months after crown-lengthening surgery, which decreased the crown length gained at the time of surgery. This rebound was found to be related to PB and post-suturing position of flap margin relative to the osseous crest.

Literature suggests that the SGT is predetermined and that placing the FGM coronal to the osseous crest at the completion of crown-lengthening surgery could provide better guideline to the restorative dentist because the gingival tissue may take a long time to reach final height and contour.[12,16,17] However, no data are provided to support the aforesaid statement.

The present study attempted to throw some light at this formerly lesser explored aspect. It was observed that SGT dimensions established 6 months after surgical crown lengthening (3.05 mm) were statistically significantly different from the presurgical dimensions (3.50 mm), and stability of crown length gained at surgery depended to a larger extent on the position of flap margin at the time of suturing. The results obtained are in accordance with a recent study by Perez et al.,[18] who observed a mean overall reduction of 0.56 mm in the preoperative SGT measurement at the TT sites 6 months after crown-lengthening surgery. A histometric study[22] after crown-lengthening surgery in monkeys also reported a significant reduction of 0.69 mm in the SGT for the maxillary sites and 0.12 mm for the mandibular sites 12 weeks after surgery, which in the present study was also recorded as 0.70 mm at the end of 3 months.

The findings of the present study are also corroborated by Deas et al.,[20] with nearly 80% of the total rebound occurring at 3 months after crown lengthening, similar to that in the present study. They also found tissue rebound to be related to the post-surgical flap position. In another study,[19] a significant tissue rebound was observed 12 months after surgical crown lengthening. Lesser bone reduction with placement of flaps at the osseous crest after suturing could have contributed to the greater rebound observed. Lanning et al.[15] also observed a considerable tissue rebound by 3 months after surgery in which the flaps were sutured at the osseous crest. However, FGM was found to remain stable from 3 to 6 months, which was attributed to greater bone reduction performed. Conversely, Brägger et al.[21] reported a clinically insignificant

Table 3.

Tissue Rebound at 6 Months Related to Post-Suturing Flap Position (mean ± SD)

Distance of Flap Margin From Osseous Crest After Suturing	TT Sites	AA Sites	NA Sites
0 to 1 mm	1.42 ± 0.40	—	1.11 ± 0.43
>1 to 2 mm	1.02 ± 0.45	0.92 ± 0.32	0.71 ± 0.39
>2 to 3 mm	0.50 ± 0.44	0.40 ± 0.28	0.23 ± 0.32
>3 mm	0.14 ± 0.48	0.11 ± 0.31	–0.15 ± 0.31

rebound of 0.05 mm by the end of 6 months. A greater osseous resection and suturing the flaps somewhat coronal to the osseous crest might have been the plausible reasons for the stability of crown height gained over time, similar to the group of the present study in which flaps were sutured at ≥3 mm from the osseous crest. Although the crown lengthening achieved will always be in accordance with the amount of bone reduction performed, the relationship between crown lengthening attempted versus achieved can only be interpreted in terms of tissue rebound, which in turn is influenced by a number of factors, with post-suturing position of flap margin being an important one.

The other factor found to significantly influence the tissue rebound is the PB of the individual. Clinical observations have led to the identification of two basic PBs: the more prevalent thick-flat type and the thin-scalloped type.[27-31] Biotype assessment based on visibility of periodontal probe through the gingival margin has been shown to be a simple, reliable, and reproducible method for gingival thickness assessment in routine practice[26] and was therefore used in the present study. Only one study[19] has assessed the role of PBs on the amount of tissue rebound after crown lengthening and, similar to the present study, found that mean tissue regrowth in patients with thick biotype was significantly greater than those with thin biotype. It was also observed in the present study that, among different tooth types, molars exhibited a slightly greater tendency for tissue rebound than the others at the end of 6 months.

A significant mean decrease in PD was observed at 6 months. Some studies[18,20] had a similar observation, whereas others either recorded no change[15,19] or an increase[21] in PDs at 6 months. TSP was proven to be a reliable tool in estimating SGT dimensions in the present study, in harmony with previous studies,[18,32,33] showing >95% agreement with DBLs for all site types. All measurements in the present study were recorded with a manual calibrated probe to the nearest 0.5 mm, inevitably resulting in some amount of rounding error (±0.5 mm). However, using a high-precision instrument to record to the nearest 0.1 mm or so may be the best to evaluate the subtle changes and reduce this error.

CONCLUSIONS

The present study established that suturing the flap ≥3 mm from the osseous crest after crown-lengthening surgery resulted in a tissue rebound that was both clinically and statistically insignificant. After surgery, there is a tendency for the formation of a new supracrestal gingival complex with its mean dimensions at 6 months observed to be 0.45 mm less than those present before surgery. Accordingly, considering preoperative SGT measurements to estimate the amount of supracrestal tissue formed after surgery may slightly overestimate the amount of exposed tooth structure desired. Hence, the osseous reduction to be performed may require additional considerations, such as tissue biotype, tooth type, and postoperative position of gingival margin in relation to osseous crest. Thus, the authors concluded the following: 1) to achieve stable and predictable results after crown-lengthening surgery, greater bone reduction with lesser apical positioning of flaps is required; 2) TSP is a reliable alternative to DBL measurement; and 3) identification of PB is important before crown-lengthening surgery because the presence of thick biotype will call for greater bone reduction in light of greater expected tissue rebound.

ACKNOWLEDGMENT

The authors report no conflicts of interest related to this study.

REFERENCES

1. Bader JD, Rozier RG, McFall WT Jr., Ramsey DL. Effect of crown margins on periodontal conditions in regularly attending patients. *J Prosthet Dent* 1991;65:75-79.
2. Bader JD, Rozier RG, McFall WT Jr. The effect of crown receipt on measures of gingival status. *J Dent Res* 1991;70:1386-1389.
3. Srdjak KJ, Plancak D, Maricevic T, Dragoo MR, Bosnjak A. Periodontal and Prosthetic aspect of biological width. Part I: Violation of biologic width. *Acta Stomatol Croat* 2000;34:195-197.
4. Pama-Benfenati S, Fugazzotto PA, Ferreira PM, Ruben MP, Kramer GM. The effect of restorative margins on the postsurgical development and nature of the periodontium. Part II. Anatomical considerations. *Int J Periodontics Restorative Dent* 1986;6:64-75.
5. Tal H, Soldinger M, Dreiangel A, Pitaru S. Periodontal response to long-term abuse of the gingival attachment by supracrestal amalgam restorations. *J Clin Periodontol* 1989;16:654-659.
6. Nevins M, Skurow HM. The intracrevicular restorative margin, the biologic width, and the maintenance of the gingival margin. *Int J Periodontics Restorative Dent* 1984;4:30-49.
7. Maynard JG Jr., Wilson RD. Physiologic dimensions of the periodontium significant to the restorative dentist. *J Periodontol* 1979;50:170-174.
8. de Waal H, Castellucci G. The importance of restorative margin placement to the biologic width and periodontal health. Part II. *Int J Periodontics Restorative Dent* 1994;14:70-83.
9. Allen EP. Surgical crown lengthening for function and esthetics. *Dent Clin North Am* 1993;37:163-179.
10. Gargiulo AW, Wentz F, Orban B. Dimensions and relations of the dentogingival junction in humans. *J Periodontol* 1961;32:261-267.
11. Vacek JS, Gher ME, Assad DA, Richardson AC, Giambarresi LI. The dimensions of the human

dentogingival junction. *Int J Periodontics Restorative Dent* 1994;14:154-165.
12. Ingber JS, Rose LF, Coslet JG. The "biologic width" — A concept in periodontics and restorative dentistry. *Alpha Omegan* 1977;70:62-65.
13. Rosenberg ES, Garber DA, Evian CI. Tooth lengthening procedures. *Comp Contin Educ Gen Dent* 1980;1:161-172.
14. Wagenberg BD, Eskow RN, Langer B. Exposing adequate tooth structure for restorative dentistry. *Int J Periodontics Restorative Dent* 1989;9:322-331.
15. Lanning SK, Waldrop TC, Gunsolley JC, Maynard JG. Surgical crown lengthening: Evaluation of the biological width. *J Periodontol* 2003;74:468-474.
16. Kois JC. Altering gingival levels: The restorative connection. Part I: Biologic variables. *J Esthet Dent* 1994;6: 3-9.
17. Smukler H, Chaibi M. Periodontal and dental considerations in clinical crown extension: A rational basis for treatment. *Int J Periodontics Restorative Dent* 1997;17: 464-477.
18. Perez JR, Smukler H, Nunn ME. Clinical evaluation of the supraosseous gingivae before and after crown lengthening. *J Periodontol* 2007;78:1023-1030.
19. Pontoriero R, Carnevale G. Surgical crown lengthening: A 12-month clinical wound healing study. *J Periodontol* 2001;72:841-848.
20. Deas DE, Moritz AJ, McDonnell HT, Powell CA, Mealey BL. Osseous surgery for crown lengthening: A 6-month clinical study. *J Periodontol* 2004;75:1288-1294.
21. Brägger U, Lauchenauer D, Lang NP. Surgical lengthening of the clinical crown. *J Clin Periodontol* 1992;19: 58-63.
22. Oakley E, Rhyu IC, Karatzas S, Gandini-Santiago L, Nevins M, Caton J. Formation of the biologic width following crown lengthening in nonhuman primates. *Int J Periodontics Restorative Dent* 1999; 19:529-541.
23. Herrero F, Scott JB, Maropis PS, Yukna RA. Clinical comparison of desired versus actual amount of surgical crown lengthening. *J Periodontol* 1995;66:568-571.
24. Silness J, Löe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand* 1964;22:121-135.
25. Löe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963;21: 533-551.
26. De Rouck T, Eghbali R, Collys K, De Bruyn H, Cosyn J. The gingival biotype revisited: Transparency of the periodontal probe through the gingival margin as a method to discriminate thin from thick gingiva. *J Clin Periodontol* 2009;36:428-433.
27. Sanavi F, Weisgold AS, Rose LF. Biologic width and its relation to periodontal biotypes. *J Esthet Dent* 1998; 10:157-163.
28. Müller HP, Heinecke A, Schaller N, Eger T. Masticatory mucosa in subjects with different periodontal phenotypes. *J Clin Periodontol* 2000;27:621-626.
29. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. *J Clin Periodontol* 1991;18:78-82.
30. Olsson M, Lindhe J, Marinello CP. On the relationship between crown form and clinical features of the gingiva in adolescents. *J Clin Periodontol* 1993;20:570-577.
31. Kao RT, Fagan MC, Conte GJ. Thick vs. thin gingival biotypes: A key determinant in treatment planning for dental implants. *J Calif Dent Assoc* 2008;36:193-198.
32. Greenberg J, Laster L, Listgarten MA. Transgingival probing as a potential estimator of alveolar bone level. *J Periodontol* 1976;47:514-517.
33. Ursell MJ. Relationships between alveolar bone levels measured at surgery, estimated by transgingival probing and clinical attachment level measurements. *J Clin Periodontol* 1989;16:81-86.

Correspondence: Dr. Ritika Arora, Department of Periodontics, Post Graduate Institute of Dental Sciences, Rohtak 124001, Haryana, India. E mail: drritika44@gmail.com.

Submitted March 8, 2012; accepted for publication August 23, 2012.