

# Surgical lengthening of the clinical tooth crown

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## SUMMARY

To understand why the crown lengthening may be desirable, a review of periodontal anatomy is in order. The odontologists know, but often underestimate importance of periodontal tissues health to restoration of defected teeth or dental arches. In order to avoid pathological changes, to predict treatment results more precisely, it is necessary to keep gingival biological width unaltered during teeth restoration. If there are less than 2 mm from restoration's margin to marginal bone clinical crown lengthening possibility should be considered in dental treatment plan. The choice depends on relationship of crown-root-alveolar bone and esthetical expectations. In order to keep margins of restoration supragingivally the distance from marginal bone to margins of restoration should not be less than 3 mm. Ideally the margins of restoration should be supragingivally or in the same level as marginal gingiva. When the margins of restoration are prepared subgingivally, the distance from marginal gingiva to margins of restoration should not be more than 0.7 mm. To continue dental treatment in operated area is recommended not earlier than in 4 weeks, and making restorations in esthetical area - not earlier than in 6 weeks.

**Key words:** crown lengthening, gingival biological width, periosurgery.

## INTRODUCTION

The odontologists know, but often underestimate importance of periodontal tissues health to restoration of defected teeth or dental arches. It is necessary to prepare periodontal tissues properly before restorative treatment to ensure good form, function and esthetic of masticatory apparatus and patient comfort. In time bad quality restorations alters periodontal tissues. Precision of restorations is important as well as relationship with periodontium. Sometimes even precise restoration can induce inflammation of periodontal tissue. It is important to know what is gingival biological width, what does happen when it is altered, what is lengthening of the clinical crown, when it should be done. There is a lot of literature on separate questions, but it is incoherent, non-accentuated. We tried to summarize and systematically present data from literature.

*Clinical crown of the tooth* is the distance from gingival margin to incisal edge or occlusal surface of the tooth.

This distance should be increased when:

- margins of caries lesion are subgingivally;
- margins of tooth crown fractures are subgingivally;
- tooth crown is too short for retention of restoration;
- there is excess of gingiva and anatomical tooth crown is opened partially.

In these cases, except the last, it is necessary to evaluate the gingival biologic width (GBW), to clear out if it is not altered, will it remain healthy after tooth restoration.

*Gingival biological width* (biologic membrane, dentogingival attachment) is the area of gingiva attached to the surface of the tooth coronary from the alveolar bone. This determination is based on the study of Garguilo A. W., Wentz F. and Orban B. in 1961 on dentogingival junction of cadavers [1]. It was established the width necessary for gingiva to attach to the tooth. They studied 287 teeth of 30 cadavers and established the relationship between marginal alveolar bone, connective tissue attachment (CTA), epithelial attachment (EA) and gingival sulcus (GS). Results showed the mean connective tissue attachment is 1.07 mm, epithelial attachment – 0.97 mm, dental sulcus – 0.69 mm. Gingival biological width (GBW) was calculated by adding widths of connective tissue attachment and epithelial attachment:  $GBW = CTA + EA = 2.04$  mm (Fig. 1). It was calculated mean values, though values in the study varied, especially width of epithelial attachment (1 mm to 9 mm), however connective tissue attachment width value was almost constant [1].

The studies of Vacek J. S. and co-authors (1994) confirmed previous results of Garguilo A. W., Wentz F. and Orban B. (1961). After examination of 171 teeth of cadavers values were established: connective tissue attachment – 0.77 mm, epithelial attachment – 1.14 mm, depth of gingival sulcus – 1.34 mm. It was stated, the mean value of gingival biological width is 2 mm and value of connective tissue attachment almost constant [2].

## ALTERATIONS OF GINGIVAL BIOLOGICAL WIDTH

Direct or indirect restorations of tooth crown defects with margins located in the gingival biological width area induce gingival inflammation, loss of connective tissue

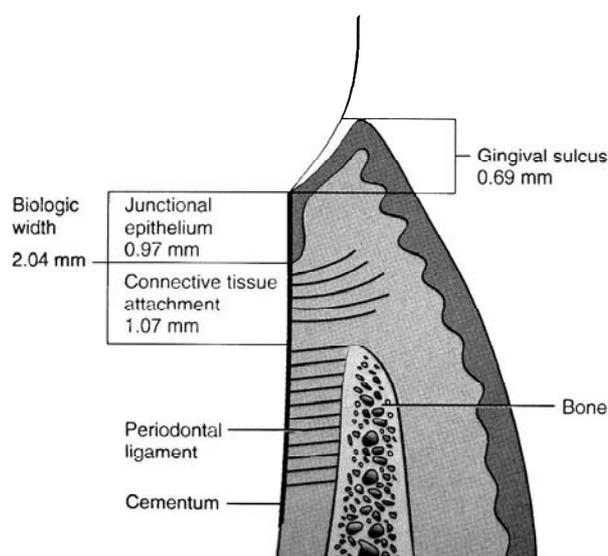
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**Fig. 1.** Gingival biological width (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)

attachment and unpredictable bone loss. Clinically it could be manifested as:

- gingival bleeding,
- periodontal pocket formation,
- gingival retraction.

Histological and clinical investigations of periodontal tissues response to restorations with margins altering gingival biological width confirmed these statements.

Newcomb G. M. (1974) examined 66 front teeth crowns with margins in various distance from epithelial attachment and proved: deeper subgingivally restoration margins are, severer inflammation they course [3].

Parma-Benfenati S. and co-authors (1986) observed bone resorption to 5 mm in the dog teeth when restoration margins were near alveolar bone, and no bone resorption when restoration margins were 4 mm from alveolar bone. Severe bone resorption could be found in the areas of thin cortical and interdental bone [4].

Tal H. and co-authors (1989) proved that alterations of gingival biological width cause loss of periodontal liga-

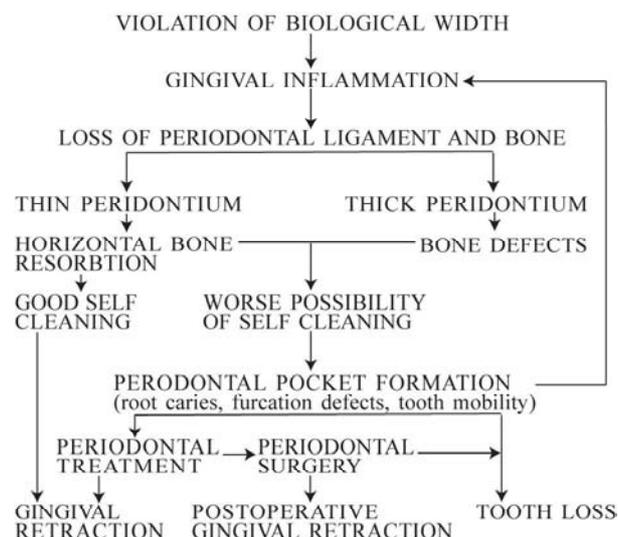
**Table 1.** Periodontal tissues response to the alterations of biological width (Tal H. et al. 1989)

	Gingival retraction	Bone loss
Test group	3.16 mm	1.17 mm
Control group	0.5 mm	0.15 mm

**Table 2.** Stages of gingivitis (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)

Stage	Time (Days)	Blood Vessels	Junctional and Sulcular Epithelium	Predominant Immune Cells	Collagen	Clinical Findings
I. Initial Lesion	2 - 4	Vascular dilatation, Vasculitis	Infiltrated by PMNs	PMNs	Perivascular loss	Gingival fluid flow
II. Early Lesion	4 - 7	Vascular proliferation	Same as Stage I Rete peg formation Atrophic areas	Lymphocytes	Increased loss around infiltrate	Erythema Bleeding on probing
III. Established Lesion	14 - 21	Same as Stage II plus blood stasis	Same as Stage II but more advanced	Plasma cells	Continued loss	Changes in color, size, texture, etc.

PMNs, Polymorphonuclear neutrophils

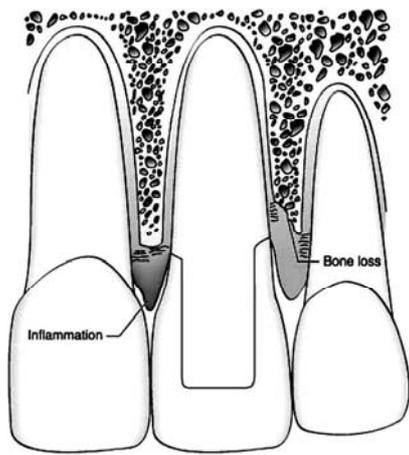


**Fig. 2.** Periodontal tissues response and possible reaction to the biological width alteration

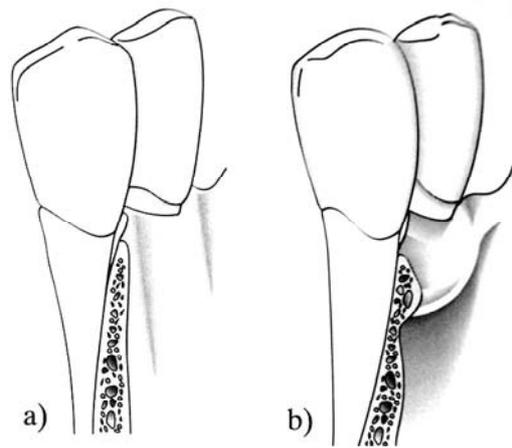
ment. It was prepared 43 Class V cavities in 43 dog teeth with margins near alveolar bone, and in control group – with margins in cements enamel junction. All cavities were filled with amalgam. After one year gingival retraction and bone loss was pronounced more in experimental group than in control group (Table 1) [5].

Gunay H. and co-authors (2000) showed how margins of restorations in area of gingival biological width cause pathology of periodontium. It was evaluated 116 restored and 82 healthy teeth of 41 patients. After 2 years results showed formation of periodontal pockets and increased index of gingival bleeding in the areas with distance less than 1 mm from restoration margins to alveolar bone [6].

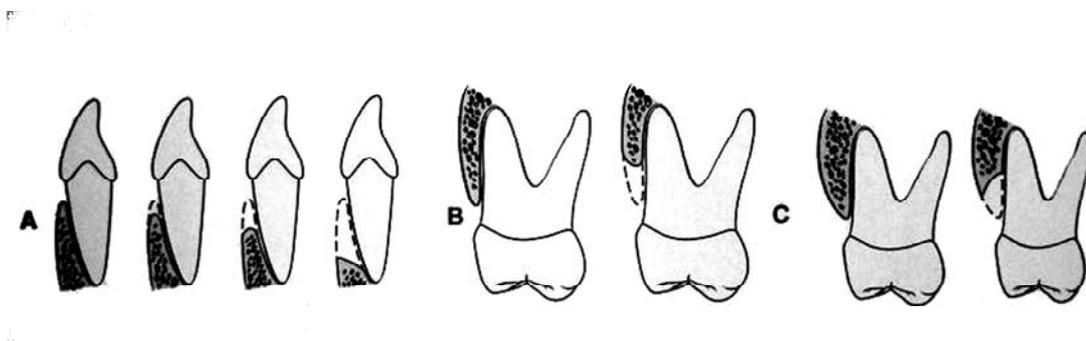
Other studies comparing relationship of restorations and gingival biological width showed similar results. It is necessary minimal distance of 3 mm from restoration to alveolar bone to keep periodontium healthy [7, 8, 9, 10, 11, 12, 13, 14]. According data of literature we created scheme showing how periodontium reacts to alteration of gingival biological width (Fig. 2). It is established minimal width of 2 mm needed gingiva to attach to bone. It could be larger but just because of epithelial attachment; connective tissue attachment is constant (CTA = 1 mm). Gingival biological width would be altered if there be less than 2 mm from restoration margin to alveolar bone. In that case gingival



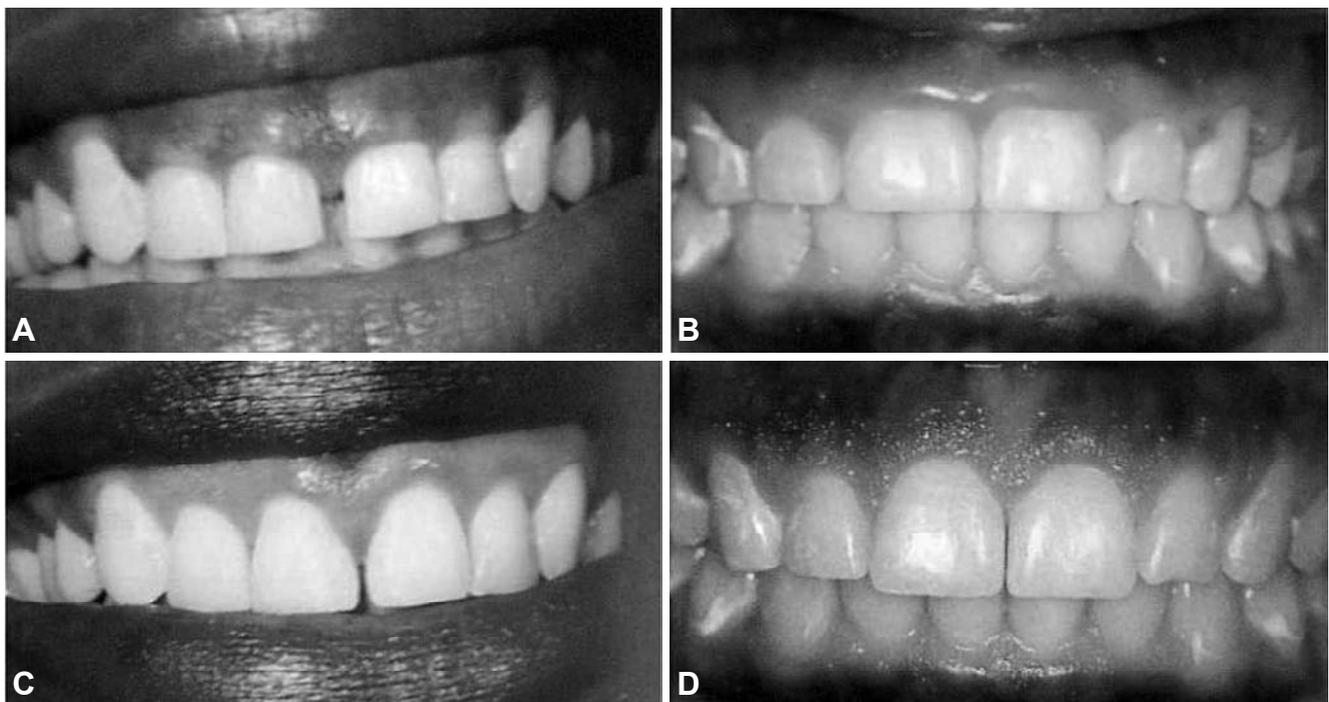
**Fig. 3.** Ramifications of a biologic width violation if a restorative margin is placed within the zone of the attachment. (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)



**Fig. 4.** Types of marginal bone: a) thin marginal bone, b) thick marginal bone (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)



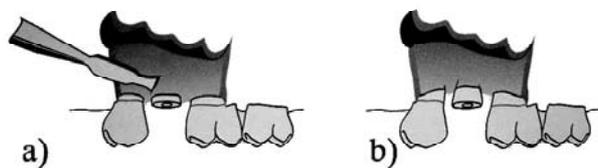
**Fig. 5.** A lower incisor with thin labial bone (A). Bone loss can become vertical only when it reaches thicker bone in apical areas. Upper molars with thin facial bone, where only horizontal bone loss can occur (B). Upper molar with a thick facial bone, allowing for vertical bone loss (C) (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)



**Fig. 6.** Excessive gingival display resulting in an unproportional appearance of the clinical crown: (a-b) pretreatment view, c) post-treatment view showing the color changes of anterior gingiva, d) post-treatment view showing the same color of anterior gingiva (Lindhe J, KarringTh, Lang N. P. Clinical Periodontology and Implant Dentistry, 4-th edition, 2003)



**Fig. 7.** The excessive display of gingiva is caused by vertical maxillary excess and a long midface (Lindhe J, KarringTh, Lang N. P. Clinical Periodontology and Implant Dentistry, 4-th edition, 2003)



**Fig. 8.** The principles of osseous resection require that bone be removed from the adjacent teeth to create a gradual rise and fall in the profile of the osseous crest (a). This causes a loss of attachment apparatus and recession on adjacent teeth as well (b) (Lindhe J, KarringTh, Lang N. P. Clinical Periodontology and Implant Dentistry, 4-th edition, 2003)

inflammation (gingivitis) starts, it can be seen all typical inflammation characteristics (Table 2) [15].

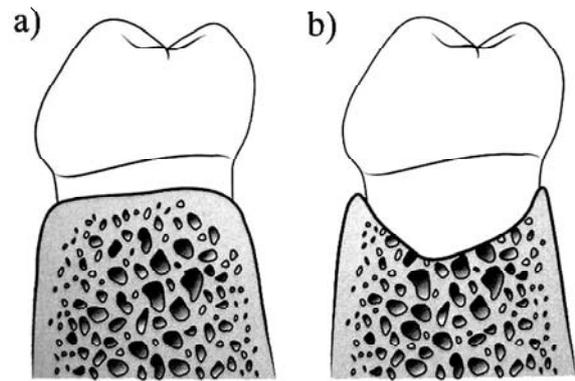
Human body tries to repair this dimension of 2 mm by resorbing bone as much as needed to create the space for gingival attachment between restoration and alveolar bone. Gingival inflammation depending on status of immune system, earlier or later, induces loss of periodontal ligament and bone of this area, till it is enough width for gingival attachment (Fig. 3) [16].

The consequences of this change could be various. It depends on biotype of individual periodontium. There are two biotypes of periodontium and intermediate variants (Fig. 4) [17]:

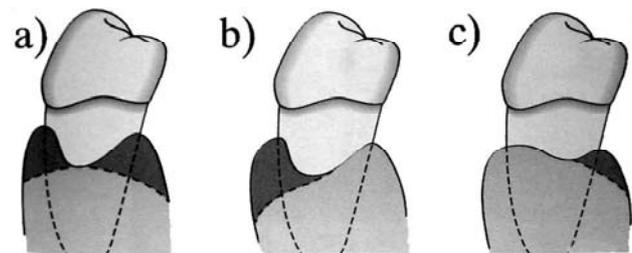
1. Thin periodontium – thickness of attached gingiva less than 1 mm, width – 3.5-5 mm, thin marginal bone.
2. Thick periodontium – thickness of attached gingiva to 1.3 mm, width 5-6 mm and more, thick marginal bone.

In both cases periodontal pocket could form and gingival retraction could happen after loss of periodontal ligament and bone (Fig. 5). When periodontium is thin marginal bone resorbs horizontally quicker and if cleaning of the area is good gingival retraction happens often. However, if cleaning is bad the inflammation persists, bone resorbs and periodontal pocket forms.

In case of thick periodontium gingival retraction is rarer and bone loss is more slowly; however, bone defects and unfavorable bone contour form more often. It causes worse possibility of self cleaning, periodontal pocket formatting and probable development of:



**Fig. 9.** Bone contour: a) normal bone contour, b) osseous crater (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)



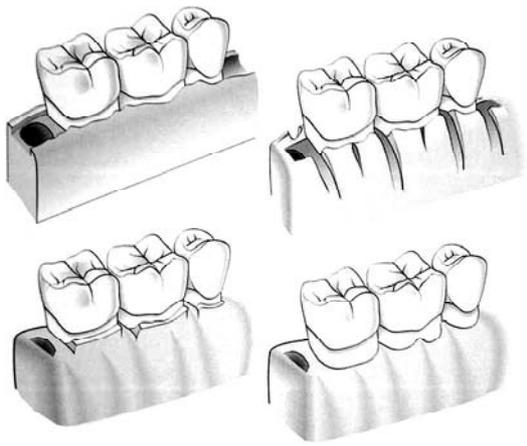
**Fig. 10.** Interproximal craters (a-c). The shaded areas illustrate different techniques for the management of such defects (M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)

- root caries,
- furcation defects,
- tooth mobility because of loss of tooth attachment apparatus
- tooth loss, etc.

In order to avoid pathological changes, to predict treatment results more precisely, it is necessary to keep gingival biological width unaltered during teeth restoration [18]. If there are less than 2 mm from restoration's margin to marginal bone clinical crown lengthening possibility should be considered in dental treatment plan. The choice depends on relationship of crown-root-alveolar bone and esthetical expectations. The clinical tooth crown could be lengthened surgically or combining methods of orthodontic eruption and surgery.

#### SURGICAL LENGTHENING OF CLINICAL TOOTH CROWN

Surgical treatment is faster and more favorable for indirect restoration when higher clinical tooth crown is necessary [19]. Depending on clinical situation bone should be removed so that enough space for gingival biological width and gingival sulcus formatting would be created. It is necessary to consider situations, when after removing bone around the tooth, the level could be reached, in which periodontal attachment structures will be too weak to withstand tooth function, or will be altered furcation area, or will be reached unfavorable relationship of crown-root. Then treatment plan should be reconsidered.



**Fig. 11.** Bone reduction: osteoplastic and osteoectomy (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)

The methods of surgical clinical tooth crown restorations are:

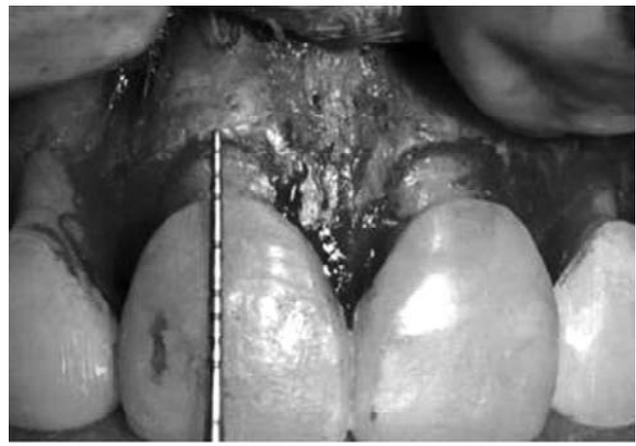
1. Gingivectomy;
2. Apically positioned flap;
3. Apically positioned flap with bone reduction:
  - a) Osteoplastic – bone reduction without periodontal ligament altering
  - b) Osteoectomy – bone and periodontal ligament reduction

Indications of gingivectomy, apically positioned flap and apically positioned flap with osteoplastic for clinical tooth crown lengthening are limited because these procedures do not increase the distance between margins of defect and marginal bone. These methods could be used in case of “gummy smile”, when, because of excess of gingiva, anatomical tooth crown is opened partially but gingival biological width is not altered. Marginal gingiva in individuals with healthy periodontium is 1 mm coronally from cementoenamel junction. In some individuals this distance is longer and tooth crown visually seems shorter. In that case surgical method is used to lengthen tooth crown [20, 21, 22]. It is chosen according biotype of periodontium [37]:

- in case of thin periodontium with sufficient width of attached gingiva gingivectomy is recommended;
- in case of thin periodontium with short width of attached gingiva apically positioned flap is recommended;
- in case of thick periodontium apically positioned flap with osteoplastic is recommended.

Performing gingivectomy it is necessary to pay attention to pigmentation especially in black individuals. Performing gingivectomy in conventional way (external oblique incision) pigment is removed and the color of gingiva change after healing. It is necessary to inform the patient (it is worth to have visual material) and incision to extend to premolars to hide areas of different pigmentation. If patient requires keeping pigmentation gingivectomy is carried out applying internal oblique incision (Fig. 6) [37, 38].

Some patients show wide area of gingiva during smiling but have proportional relationship of tooth crown, alveolar bone and gingiva. In these cases there are excess of maxillary bone vertical high (Fig. 7). The treat-



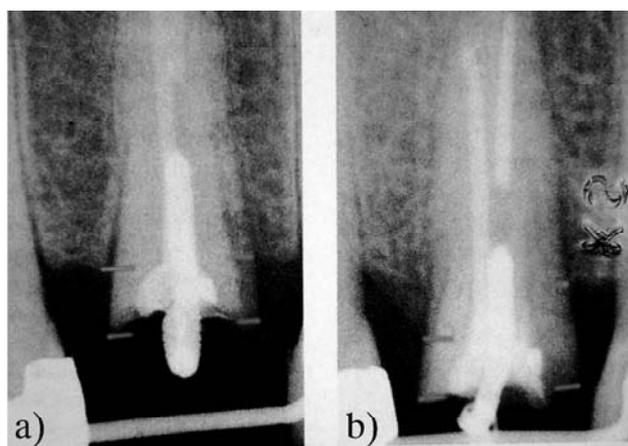
**Fig. 12.** The surgical guide during the surgery (Newman M. G. Takei H. H. Carranza F. A. Carranza's Clinical Periodontology 9-th edition, 2002)

ment plan includes operations of maxillary bone reconstruction [37].

The main method performing surgical clinical tooth crown lengthening is apically position flap with osteoectomy and osteoplastic [18]. The technique of incisions depends on gingival biotype. The mucoperiosteal flap is lifted according extend of operation and visual area. In order to form continuous gingival and bone contour adjacent teeth are included (Fig. 8). If there are or it forms during osteoectomy unfavorable bone contour (Fig. 9), osteoplastic should be done to get most acceptable bone contour (Fig. 10 and 11) [23, 24, 25, 26, 27].

Most of scientists agree that it is necessary minimum 3 mm distance from marginal bone to restoration margin to keep it supragingivally: CTA + EA + GS (1 + 1 + 1). During prosthetic work, according recommendations, crowns should cover inlays or fillings 1.5-2 mm and all distance from margin of tooth/root defect to marginal bone should be 5 mm. This width should be created during periosurgery. This (mathematic) calculating is not correct. In 1970 Wilderman M. N. and co-authors established spontaneous bone resorption of 0.6 – 0.8 mm in one year after surgical procedure [29]. Oakley E. and co-authors (1999) performed study on monkeys to clear out why during healing after surgical procedures on marginal bone it resorbs and how gingival-tooth attachment forms after surgical interventions. Three monkeys received surgical front teeth crowns lengthening. Histological examination showed recovering of gingival biological width, formatting of epithelial attachment to marginal bone and formatting of connective tissue attachment during marginal bone resorption [30]. This study denies the opinion that connective tissue attachment forms coronally from marginal bone and proved that connective tissue attachment forms on account of resorption of marginal bone.

Surgical lengthening of clinical tooth crown is performed before prosthetic to increase retention of restorations in case of short clinical crowns. The margins of primary preparation is reference point for surgeon who is asked to increase the distance of 1-2-3 mm to marginal bone. The best way is to make temporary crowns or tray-guide with the margins of final restoration before surgical clinical tooth crown lengthening. Doing so surgeon could



**Fig. 13.** Accelerated orthodontic eruption (rapid tooth eruption) in conjunction with fibrotomy procedure (a, b). The radiographs show the "positive" angular crest on the "control" distal side (blue marks) and the unchanged crest on the mesial "test" side (red marks) (Lindhe J, Karring Th, Lang N. P. Clinical Periodontology and Implant Dentistry, 4-th edition, 2003)

define more exactly the relationship between margins of final restoration and marginal bone during surgical procedure (Fig. 12) [31, 32, 33].

If surgical clinical tooth crown lengthening is performed in the area of front teeth, it is necessary to solve esthetical problem: the crown of particular tooth would be different from adjacent teeth and the contour of marginal gingiva would change. In order to get continuing contour of marginal gingiva it is necessary to evaluate: smile line (is marginal gingiva seen during smiling or not) and gingival contour of teeth in esthetical area. In any case it is necessary to clear up esthetical expectations of the patient, to prove him (her) the orthodontic eruption is necessary as well as surgery for optimal result. It is easier to explain patients using visual means.

The study of Bräger U., Lauchenauer D. and Lang N. P. (1992) showed how periodontal tissues change after surgical clinical tooth crown lengthening. After six weeks after operation attachment level and probing depth did not change, the level of marginal gingiva established during operation almost precisely corresponds to the level of marginal gingiva after healing. Between 6 weeks and 6 months in 85 % of cases there were no or minimal  $\pm 1$  mm changes of marginal gingiva level. In 12 % of cases gingival retraction occurs more than 1 mm [33]. According the study final restoration should be made not earlier than 6 weeks after operation, and because of possible retraction it is recommended to wait longer in esthetical areas. The other important reason to delay dental treatment in the operated area is still week, easy injured gingiva. It is established, the epithelial basal membrane – *membrana basalis* (lat.) bonding epithelium with connective tissue under it, totally recovers just after 4 weeks [34, 35].

The complications after surgical clinical tooth crown lengthening could be such [36]:

- Unsatisfactory esthetic, especially in front teeth area:
  - gingival retraction – change of marginal gingiva contour;
  - possible loss of gingival papilla – opening of interdental spaces;
  - clinical tooth crown higher than adjacent teeth.

- Unfavorable crown-root relationship. Resection of marginal bone leads to longer distance to occlusal curve.
- Loss of periodontal ligament and marginal bone of adjacent teeth. In order to create continues bone contour it is necessary to resect marginal bone and periodontal ligament.

The orthodontic tooth eruption should be performed to avoid negative sequences of surgical treatment, especially in esthetical area. There are two methods of treatment [37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58]:

1. Slow;
2. Accelerated.

Slow orthodontic eruption requires slight force to apply. All periodontal structures: gingival, periodontal ligament and alveolar bone are extruded during slow eruption of root/tooth. The distance between marginal bone and margins of root/tooth defect do not change. The surgical procedure as well as orthodontic would be necessary if gingival biological width altered. The periodontal structures should be lifted so that after osteoectomy (leveling of marginal bone of particular and adjacent teeth) enough space would be created for self-formation of gingival biological width and gingival sulcus. Applying this method the loss of periodontal structures of adjacent teeth could be avoided and the same bone and gingival level kept. The same treatment method is applied in order:

- To reduce depth of periodontal pockets in case of vertical bone loss;
- To increase height of alveolar bone and gingival level in the area of roots/teeth when it is unfavorable dental treatment prognosis and extraction is planed [59, 60, 61, 62, 63, 64].

Applying accelerated orthodontic rapid tooth eruption tooth is pulled from alveola while marginal bone and periodontal structures do not move. They stay at the primary level. The harder force is used and fibrotomy, i. e. cutting of connective tissue attachment fibers, is performed every 7-10 days to maintain inflammation of this area (near marginal bone). Inflammatory trauma does not allowed marginal bone to follow after root of tooth coronally. This was proved in the test applying fibrotomy in the medial side of orthodontically erupting tooth without touching of distal side (Fig. 13). If changes of marginal bone still happen in coronal direction, it could be corrected surgically. This method could not be applied when vertical bone resorbition is observed near particular tooth.

The orthodontic eruption is performed with fixed orthodontic appliances. This method could be difficult or impossible if there are no adjacent teeth or loss of a lot of teeth.

The orthodontic treatment has a lot of advantages performing clinical tooth crown lengthening but it is relatively long and expensive, uncomfortable for patient, and surgical treatment is still necessary.

It would be ideally for periodontium to keep margins of restoration supragingivally [16]. Inaccuracy between restoration margin and preparation step not influencing gingival biological width alters periodontium less than ideally made and fitted crown altering gingival biologic width. The step should be prepared subgingivally in esthetical area (sometimes it could be avoided by making

full ceramic crowns or ceramic-bonded-to-metal crowns with cervical material). The depth of gingival sulcus, the bottom of it (which is epithelial attachment) should be the reference point trying to avoid gingival biological width injuring. It should be considered that probing healthy gingiva the probe penetrates 0.5 mm into the epithelial attachment.

Before tooth restoration the gingiva should be healthy without any sign of inflammation. Then these rules could be followed [16]:

- If gingival sulcus is 1.5 mm or less, then margins of restoration is prepared to 0.5 mm subgingivally;
- If gingival sulcus is 1.5 – 2 mm, then margins of restoration is prepared to 0.7 mm subgingivally;
- If gingival sulcus more than 2 mm, especially in esthetical area from vestibular side then gingivectomy is recommended and margins of restoration is prepared to 0.5 mm subgingivally.

The gingivectomy is recommended because the deeper gingival sulcus is, less predictable stability of marginal gingiva and more severe gingival retraction could be. Attempts to prepare margins of restoration as deep as possible subgingivally and thinking, if gingival retraction would happen, margins of restoration still stay subgingivally, could give contrary results – gingival retraction, open margins of restoration or periodontal pocket. It is known, that patient could clean the area of restoration and step margin himself, when it is subgingivally not more than 0.7 mm (Fig. 14). If it is deeper the possibilities to

clean it decrease and probability of periodontal pocket formation increase [65, 66].

## CONCLUSIONS

1. Medium gingival biological width is 2 mm.
2. If the distance from marginal bone to the margins of restoration would be less than 2 mm gingival biological width would be altered. In that case tooth clinical crown lengthening should be considered before restoration.
3. In order to keep margins of restoration supragingivally the distance from marginal bone to margins of restoration should not be less than 3 mm.
4. After surgical interventions the epithelial attachment forms till marginal bone so the dimensions varies (from 1 to 9 mm) and connective tissue attachment forms during resorption of marginal bone and is almost constant (approx. 1 mm).
5. Ideally the margins of restoration should be supragingivally or in the same level as marginal gingiva. When the margins of restoration are prepared subgingivally, the distance from marginal gingiva to margins of restoration should not be more than 0.7 mm.
6. Gingivectomy is recommended in order to avoid gingival retraction, when gingival sulcus is deeper than 2 mm in esthetical area.
7. To continue dental treatment in operated area is recommended not earlier than in 4 weeks, and making restorations in esthetical area – not earlier than in 6 weeks.

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