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Supracrestal Tissue Attachment: A Narrative Review

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ABSTRACT

The supracrestal tissue attachment (SCTA) space, formerly known as biologic width, forms an organic seal around the alveolus to maintain the health of the periodontium, which in turn affects the health of the tooth. Any violation to SCTA may lead to periodontal disease thereby compromising the prognosis of the teeth. The SCTA violation can be prevented by increasing the clinical crown height by moving the bone away from the gingival margin so that restorative margins can be placed at sound tooth structure at distance away from alveolar bone crest, which can be achieved through crown lengthening surgery, orthodontic extrusion or, surgical extrusion.

No universal dimension of SCTA appears to exist. It can be different at sites even within the same individual. Although the 2 mm of SCTA advised by Garguilo et al. has been the norm for use in all clinical situations, each individual site has to be assessed separately as many studies have shown that there is large variation in the epithelial and the connective tissue attachment and even a minimum encroachment will lead to its violation. Therefore, adequate understanding of SCTA along with its preservation and maintenance is essential to ensure form, function and aesthetics of the dentition.

Keywords: Biologic width; crown lengthening; supracrestal tissue attachment.

INTRODUCTION

The periodontium has traditionally been divided into investing and supporting tissue.[1] In 1921, Gottlieb's discovery of the epithelial attachment served as the basis for understanding the biology of supporting tissue of teeth in health and disease.[2] In 1924, Orban and Kohler measured the tissue surrounding the tooth.[3] The physiologic division of the supporting tissue was outlined by Sicher in 1959 and termed it as dentogingival junction (DGJ) which was composed of epithelial and fibrous connective tissue attachment.[4]

The dimension and relationship of DGJ was first described by Gargiulo et al. in 1961. They measured its dimension in 30 human autopsies with age ranging from 19-50 years. The DGJ were measured on 287 teeth at 325 surfaces during the four phases of eruption and the mean of histologic sulcus depth (SD), junctional epithelium (JE), and connective tissue was determined to be 0.69 mm, 0.97 mm (0.711.35 mm), and 1.07 mm (1.06 1.08 mm), respectively.[5] Therefore, the dimension of DGJ measurement was 2.04 mm (1.77-2.43 mm) which then became the norm for use in all clinical situations.[6]

Based on Gargiulo work, Dr. D. Walter Cohen in 1962 coined the term biologic width (BW) while lecturing at Walter Reed Army Medical Centre.[7] Maynard and Wilson in 1979 divided the periodontium into three physiologic components: Superficial, crevicular, and sub-crevicular representing the free and attached gingiva; the distance from the gingival margin to JE, and the space analogous to BW as described by Gargiulo, respectively.[8] Ingber in 1997 described the BW as a part of supracrestal gingival tissues (SGT) that occupy the space between the base of the gingival crevice and the alveolar bone crest (ABC)[9] (Figure 1). Walton suggested the name biologic barrier to BW[10] because the epithelial and connective tissue components form a barrier around the tooth that prevents the microbial invasion.[11]

OTHER NAMES FOR SUPRACRESTAL TISSUE ATTACHMENT

In dentistry, BW along with the sulcus around teeth or an implant is sometimes called Bermuda Triangle or Devil's Triangle.[12] This triangle is a region in the western part of North Atlantic Ocean

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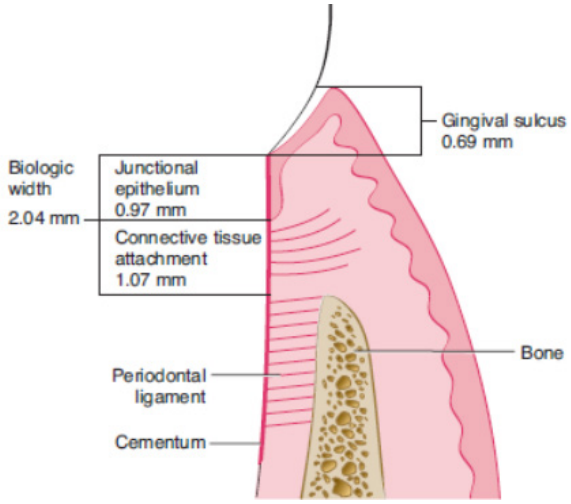

Figure 1: The biologic width.

Source: Newman MG, Takei HH, Klokkevold PR, Carranza FA. Newman and Carranza's Clinical Periodontology, 13th edition. Elsevier; 2018.[48]

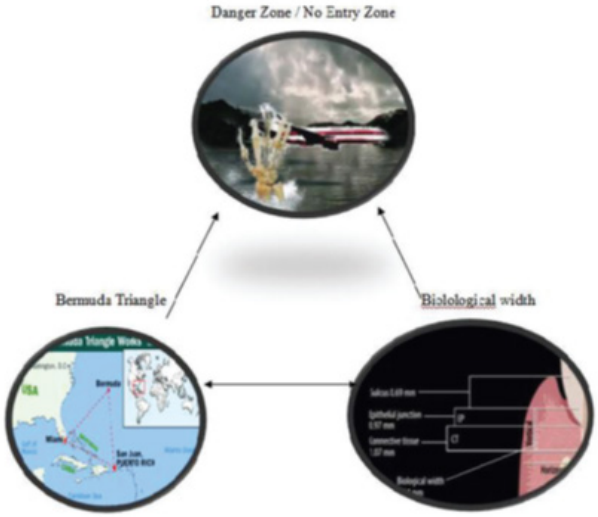

Figure 2: The bermuda triangle.

Source: Sharma A, Gupta B, Hafeez M, et al. Biological width: No violation zone. Eur J Gen Dent. 2012 Sep 1;1:137[14]

(Figure 2) where number of aircrafts and ships have disappeared under mysterious circumstances. The earliest suggestion of such unusual disappearances appeared in an article by Edward Van Winkle Jones of the Miami Herald in 1950. However, in the subsequent years, the most reputable sources denied to accept that the disappearance was due to mystery instead some hypothetical explanations was given for it.[13] Although, the mystery was solved, the area of BW had been once compared to this triangle as it is the area where dentists irrespective of their specialty lose the access and vision while extending the prosthetic or restorative margins into the subgingival area that may lead to periodontal complications, and eventually prosthetic failure.[14]

More recently, the term supracrestal tissue attachment (SCTA) has been introduced in 2017 following the World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions, co-sponsored by the American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP). They described the BW as the apicocoronal variable dimensions of the supracrestal attached tissues. Then after the term BW was replaced by SCTA and these terms can be used interchangeably.[15]

SIGNIFICANCE OF SUPRACRESTAL TISSUE ATTACHMENT

Periodontal health is of utmost importance when considering the longevity of restoration as well as of teeth.[14] Unlike other parts of the body, periodontal tissue is vulnerable to invasion by pathogens and foreign particles. The SCTA, derived from ectodermal tissue, forms an organic seal that act as an innate barrier thereby protecting the periodontal tissue from any insults.[16]

Newcomb (1974)[17] analysed 66 anterior crowns with subgingival margins of varying depths and concluded the likelihood of gingival inflammation when the margins were nearer to the epithelial attachment. Waerhaug (1978)[18] stated that the subgingival preparation with rough surface are biofilm retentive area and the inability of the patient to get access to clean deeper area further aggravates the biofilm accumulation that can cause destructive inflammation. Parma-Benfenati (1986), in beagle dogs, compared the histological response of Class V cavity with amalgam restoration placed at ABC to those placed at 4 mm supracrestal. The result showed approximately 5 mm of crestal bone loss (CBL) when restorative margins were placed nearer to the ABC, whereas, minimal CBL was observed when restorations were placed at distance from ABC.[19] Tal et al. (1989) also compared Class V cavities with amalgam restoration placed at ABC to those placed at the cementoenamel junction (CEJ) in beagle dogs. After one year followup, gingival recession and CBL were significantly severe at sites in which restoration was at or, near to ABC than those placed at CEJ.[20]

Therefore, SCTA is considered to be essential in maintaining periodontal health, especially in the cases which needs subgingival preparation, for example extensive caries, tooth fracture, inadequate crown height, increased aesthetic demands, etc.[21]

RECOMMENDED SUPRACRESTAL TISSUE ATTACHMENT DIMENSION

The SCTA width is not constant and no universal dimension of SCTA appears to exist.[10] It can be different at sites even within the same individual. It depends on location or inclination of tooth in the socket, gingival biotype, etc.[22] The SCTA dimension can be measured through (i) Histology, (ii) Clinically by bone sounding or, surgical exploration, (iii) Radiograph.[23] The average SCTA dimension has been advocated by different authors (Table 1).

The mean values of SCTA obtained from two meta-analyses ranged from 2.15-2.30 mm with large intra- and inter-individual variances (subject sample range: 0.2-6.73 mm).[22] Therefore, although the 2 mm of SCTA advised by Garguilo et al. has been the norm for use in all clinical conditions, each individual site has to be assessed separately as many studies have shown that there is large variation in the epithelial attachment whereas the connective tissue is relatively stable.[10] Moreover, a large range of value was observed even in the Gargiulo study, particularly for epithelial attachment (1-9 mm).[5]

RECOMMENDED SPACE FROM RESTORATIVE MARGIN TO ALVEOLAR BONE CREST

There is lack of consensus regarding the amount of tooth structure that must be exposed above the ABC during subgingival preparation.[24] Several

Table 1: Average supracrestal tissue attachment dimension.

Author	Cadaver	Healthy individual	Periodontitis patients
Gargiulo et al.,[5] 1961	~2.04 mm [H] (1.77 - 2.43 mm)	-	-
Vacek et al.,[49]1994	1.91 mm[H]	-	-
Lanning et al.,[21]2003	-	2.26±0.13 mm[C]	-
Al-Rasheed et al.,[50] 2005	-	1.24 mm[C]	-
Xie et al.[51] 2007	2.17 mm[H]	-	-
Novak et al.,[52] 2008	-	-	3.95±1.04 mm[C]
Shobha et al.,[53] 2010	-	1.53 - 1.80 mm[C]	-
Galgali et al.,[30] 2011	-	~1.72 mm[R***] (0.94 - 2.11 mm)	-
Alpiste-Illueca,[54] 2012	-	2.16±0.85 mm[R***]	-
Ganji et al.,[55] 2012	-	1.95 - 2.55 mm[C]	-
Cayana et al.,[56] 2013	-	1.55±0.61 mm[C]	-
Gilson Coutinho Tristao,[57] 2014	-	1.18±0.42 mm[H]	-
Gaddale et al.,[6] 2015	-	-	3.98 mm[C]
Nautiyal et al.,[58] 2016	-	1.63±0.02 mm[H]	-
Hamasni,[31] 2017	-	1.13±0.28 mm[C]	-
Kakizaki,[59] 2018	-	2.09±0.6 mm[OCT]	-
Figueiredo et al.,[60] 2019	-	1.57±0.49 mm[R**]	-
Abullais et al.,[61] 2020	-	-	2.477±0.42 mm[C] 2.657±0.49 mm[R*]
Gluckman et al.,[62] 2021	-	2.6±1 mm[R**]	-
Rani et al.,[23] 2022	-	2.44±0.64 mm[C]	-
Sah et al.,[63] 2023	-	-	3.06±0.634 mm[C]

Note: C = clinical biologic width; H = histologic biologic width; OCT = optical coherence tomography; R = radiographic biologic width; R* = intraoral periapical radiograph; R** = cone bean computed tomography; R*** = parallel profile radiography.

Table 2: Minimum dimension required from the restorative margin to the bone crest.

Authors	Measurement
Ingber et al.,[9]1977	3 mm
Palomo and Kopczyk,[64] 1978	1.5 + ½ mm
Rosenberg et al.,[65] 1980	3.5 - 4 mm
Nevins and Skurow,[33] 1984	3.0 mm
Wagenberg et al.,[66] 1989	5 - 5.25 mm
Bragger et al.,[67] 1992	3 mm
Weinberg and Eskow,[68] 2000	3.5 - 4 mm
Deas et al.,[69] (2004)	3 mm
Fletcher et al.,[24] 2011	4 mm
Antoniazzi et al.,[70] 2014	3 mm

views and/or data exists with regards to the ideal dimensions of SCTA leading to difficulties for its clinical recommendations. The dimension from the restorative margin to ABC has been advocated by different authors to maintain periodontal health (Table 2).

Although individual variations exists, there is general agreement that a minimum of 3 mm should exist from the restorative margin to ABC that allows for 2 mm of SCTA and 1 mm for sulcus.[25] A successful outcome in subgingival preparation can be achieved when few basic principles are followed along with taking into consideration that an additional 0.6-0.8 mm of CBL can occur up to one year following surgery.[26]

(i) For amalgam or composite restoration: Approximately 4 mm distance between the restorative margin and the ABC will account for individual SCTA variations.[25]
(ii) For post and core restorations: At least 5-6 mm of exposed tooth above the ABC allows for 4 mm of space between ABC and restorative margin for SCTA, and 1.5 mm ferrule length.[27]
(iii) For crown fabrication on tooth fractured or decayed at gingival margin: There should be sufficient coronal tooth exposure for adequate retention of crown along with 4 mm of distance from the restorative margin to ABC.[25]

EVALUATION OF SUPRACRESTAL TISSUE ATTACHMENT VIOLATION

1. Clinical method

Symptoms: The patient usually complains of soreness or discomfort while examining the restorative margins with periodontal probe.[16]

Signs: It includes chronic progressive gingival inflammation and bleeding on probing.[28] de Waal and Castellucci[29] described four types of periodontal response to SCTA violation:

(i) Localised infrabony pocket formation,
If subgingival restoration has reached to the SCTA zone, there is severance or destruction of connective tissue fibres which result in deepening of sulcus or, pocket formation.[1]
(ii) Localised CBL followed by gingival recession,
This is more prone with highly scalloped and thin periodontal phenotype individuals (narrow keratinised tissue width and thin cortical plate). These occurs due to physiologic response in an attempt to establish space for SCTA.[25]
(iii) Localised gingival hyperplasia with minimal CBL,
This is most frequently seen in cases of altered passive eruption when restorative borders are placed subgingivally.[16]
(iv) Combination of all.

However, it is not evident whether the effect on the periodontal tissue is caused either by dental biofilm, trauma, toxicity of dental materials or, a combination of these factors. This highlights the need for additional researches for confirming their cause-effect relationship.[15]

2. Radiographic method

These are simple, non-invasive and reproducible method to identify interproximal SCTA violations.

These are not of diagnostic use on labial or buccal and palatal or lingual aspects because of superimposition of tooth.[14] Galgali and Gontiya have described a new innovative, parallel profile radiographic technique to measure the length and thickness of the dentogingival unit.[30]

3. Bone sounding

At first, sulcus depth is measured. After achieving adequate local anaesthesia, the area is probed until the resistance of bone is felt. Then, SD is subtracted from it. If the distance is <2 mm, SCTA violation can be confirmed. However, the measurement should be repeated on more than one tooth to ensure individual and site variations.[10]

PREVENTION OF SUPRACRESTAL TISSUE ATTACHMENT VIOLATION

Evidence from histological and clinical studies suggests that even minimal encroachment to SCTA can act as an iatrogenic factor for CBL.[31] Waerhaug (1953)[32] observed that when the margin of the crown did not come closer than 0.4 mm to the base of the pocket, there is no severance of fibres so there will be no pocket formation. Nevins and Skurow (1984)[33] stated that JE or connective tissue disrupted during subgingival tooth preparation or, impressing making procedures can cause periodontal inflammation. Shillingburg[34] advocated three basic requirements for biologically acceptable restorative margins. It should;

(i) fit as close as possible to minimise the width of exposed cement,
(ii) withstand occlusal forces transmitted to them,
(iii) be located where they can be seen, easily managed, and cleaned by the patient.

To these, a fourth criterion has been added that the margins of the subgingival preparation should always be parallel to the gingival margin and must not violate the integrity of the SGT.[34] In order to provide predictable result in subgingival tooth preparation, two anatomical landmark has to be taken into considerations:[35] (i) Sulcus depth, (ii) Alveolar bone crest.

Sulcus depth - It is advisable to limit the margins at the gingival crest because clinically it is impossible to detect where the sulcular epithelium ends, and the JE begins.[33] Therefore, if subgingival preparation is needed, certain guidelines has to be followed based on the SD: (a) If SD ≤1.5 mm, the restorative margins be placed 0.5 mm below the gingival margin; (b) If SD >1.5 mm, the restorative margin be placed in half the SD; (c) If SD >2 mm, gingivectomy could be performed to lengthen the tooth and to create a 1.5 mm SD, then the patient can be treated as per rule (a).[36]

Alveolar bone crest - This determines the gingival level and a reference for the margin location.[35] Kois proposed three types of SCTA patient based on ABC[37] (Figure 3a) measured through bone sounding: (i) Normal crest patients, (ii) High crest patients, and (iii) Low crest patients (Figure 3b).

- **Normal crest patients (85%):** The proximal and midfacial measurement of ABC is 3 - 4.5 mm and

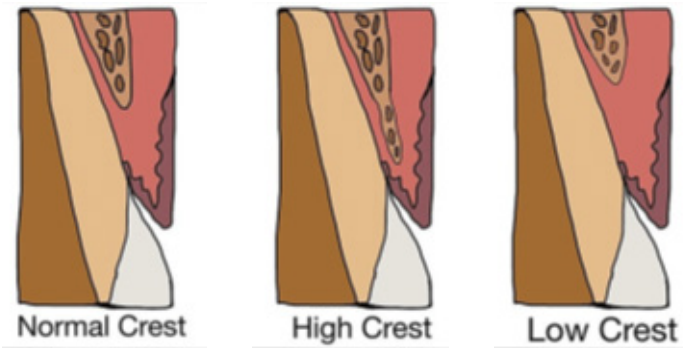

Figure 3a: Different types of osseous crests.
Source: Mulla SA, Patil A, Mali S, et al. Exploring the biological width in dentistry: A comprehensive narrative review. Cureus. 2023 Jul 18;15(7).[16]

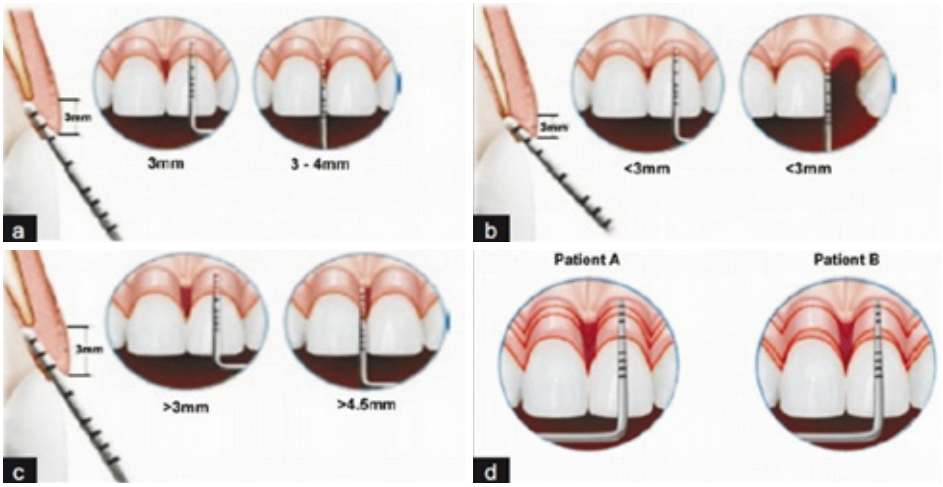

Figure 3b: SCTA in a) Normal crest on labial and interproximal site; (b) High crest on labial and interproximal site; (c) Low crest on labial and interproximal site; (d) Patient A: Low crest unstable; and, Patient B: Low crest stable.

Source: Nugala B, Kumar BS, Sahitya S, et al. Biologic width and its importance in periodontal and restorative dentistry. J Conserv Dent. 2012 Jan 1;15(1):12.[36]

3 mm, respectively. A crown margin shouldn't be closer than 2.5 mm to ABC. A crown margin that is positioned 0.5 mm subgingival has a tendency to be well tolerated by the periodontal tissues, thus having stability over time.

- **High crest patients (2%):** This is more frequently observed adjacent to edentulous area. The midfacial and proximal measurements of ABC are same that is <3.0 mm. The subgingival restorative margin close to ABC can impinge the SCTA leading to inflammation.
- **Low crest patients (13%):** The proximal and midfacial measurement of ABC is >4.5 mm and >3 mm, respectively. When the retraction cord is placed during tooth preparation, the attachment apparatus gets injured and, when it tends to heal, it results in gingival recession. Therefore, these individuals are prone to recession.[12]

The SCTA violation can be prevented by increasing the clinical crown height by moving the bone away from the gingival margin so that restorative or prosthetic margins can be placed at sound tooth structure at distance away from ABC. The concept of tooth lengthening was first introduced by D. W. Cohen in 1962.[7] The different treatment options for tooth lengthening includes:

a) Crown lengthening surgery (CLS):

It is a surgical procedure performed to create space for the re-establishment of supracrestal fibres at more apical level.[38] It aims to increase the clinical crown height of teeth for either aesthetic or restorative purposes or, combination of both.[39] The CLS can be accomplished by soft tissue excision alone or, by flap surgery with or without osseous resection.[1] The determining factors are: (i) the need of minimum of 3.0 mm of keratinised tissue (KT); and (ii) the possible need for osseous resection. If excision of soft tissue would leave at least 3.0 mm of KT then gingivectomy alone is choice of treatment. However, if there is inadequate attached gingiva and ≤3 mm of KT then flap surgery with osseous resection is needed. If <3.0 mm of KT would remain after the necessary excision, an apically positioned flap is required.[1]

Stability of supracrestal tissue attachment after crown lengthening surgery

The provisional prosthetic restoration must be adapted at three weeks after the surgery to condition the soft tissues during the period of maximal regrowth.[38] The complete healing after CLS varies and can be affected by (i) technical factors like flap positioning, osseous resection, root preparation, etc., (ii) anatomical factor like periodontal phenotype. For example, a thin phenotype may regrow and mature sufficiently within 6-12 weeks to allow for the restorative process, whereas, a thick phenotype may take as long as 6-12 months to heal completely.[1] Therefore, a waiting period of 12 weeks has been suggested for the final restoration.[40]

A narrative review by Abou-Arraj et al., 2015[41] observed that the amount of positional change can be predicted only at six months post-operatively. However, when flaps are positioned at or apical to the ABC, more than six months may be required, particularly in patients with thick periodontal phenotypes, for stable clinical outcomes. Similarly, in a systematic review by Pilalas et al. in 2016,[42] it was concluded that gingival margin may rebound largely during the first three post-operative months. The CLS resulted in stable increased crown height at six-month average. Meta-analysis regarding the stability of periodontium has not been performed because of aforementioned heterogeneity and bias risk.[42]

The CLS with or without osseous resection is rapid and preferred one.[14] However CLS at times may compromise the aesthetic and crown-root ratio; may lead to furcation involvement and mobility which further deteriorate the prognosis of teeth. In those conditions, orthodontic extrusion should be considered.

b) Orthodontic extrusion:

In 1973, Heithersay advised for the coronal placement of root of fractured teeth. It is safe, minimally invasive and highly predictable treatment, rarely associated with complications. The main disadvantage is the treatment time, with an average of four to six weeks. In addition, retention period of four weeks to six months may be required. Furthermore, fibrotomy has to be performed weekly, so high patient compliance is needed. Also, as with any orthodontic devices, it can compromise oral hygiene and the aesthetic.[43]

c) Surgical extrusion or intra-alveolar transplantation:

In this procedure, the remaining tooth structure is intentionally repositioned to a more coronal or supragingival position within its own socket. It is mainly indicated for the rehabilitation of severely compromised teeth. The most frequent complication associated with this technique is non-progressive root resorption, which can affect up to 30% of cases, fracture during extraction, progressive root resorption, CBL, and persistent mobility that may lead to tooth loss. Therefore, it is considered as a "last resort" procedure.[44]

d) Extraction followed by prosthetic rehabilitation:

It is for the patients not indicated for any of the above.

BIOLOGIC WIDTH AROUND IMPLANT

Unlike the natural tooth, BW around the dental implant could not be termed as SCTA. Animal studies provide sufficient information to state that peri-implant biologic width (PBW) not only consist of supracrestal attached tissue but it also incorporates peri-implant sulcus.[45] The mean PBW in primates was recorded to be 3.84 mm.[46] In a human histologic study, the length of the PBW was found to be 4 - 4.5 mm.[47] The PBW tends to be longer than that around teeth by the factor of 1.5 mm.[45] The clinical importance of this difference is unknown.[45]

Evidence analysis shows that the major part of the information about PBW has been derived from animal studies as not all experiments can be repeated in humans due to ethical reasons. The clinical controlled human studies are insufficient. Therefore, in the absence of available randomised controlled clinical trials, evidence is considered less reliable.[45] The details about the PBW will be updated soon in future issue.

SUMMARY

Preservation and maintenance of periodontal health is one of the keys for the longevity of teeth. The SCTA is a vital structure that forms an organic seal around the ABC to maintain the periodontal health, which in turn affects the health of the tooth. Any violation to it might lead to periodontal disease thereby compromising the prognosis of the teeth. Therefore, adequate understanding of SCTA along with its maintenance mandates to ensure form, function and aesthetics of the dentition.

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