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Crown Lengthening -A Review Article

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Abstract
Restoration of worn teeth can be made easier by surgical crown lengthening. It improves appearance and facilitates tooth preparation. Anatomical features can limit the height that can be gained through this surgical procedure. This article will highlight the biologic basis for crown lengthening procedure, the variants of surgical crown lengthening with their indications and contraindications, the orthodontic contribution to crown lengthening in the multidisciplinary approach and margin placement of prosthesis.

Key Words: *Crown lengthening, orthodontic extrusion*

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I. Introduction

In contemporary dentistry, dentists are confronted on a day to day basis with badly mutilated teeth or grossly decayed teeth. This poses problems regarding clinical decision making to determine if the tooth or teeth should be extracted or restored. We are in fact, in an age of dental implants, an era during which heroic efforts to salvage extensively damaged teeth are waning.[1] This however, doesn't mean that dentists should abandon tools which commonly are used to preserve dentition. Moreover, if the tooth can be retained, it should be preserved. Crown lengthening (CL) is one among such procedures to save mutilated tooth.

The concept of crown lengthening was first introduced by D.W.Cohen (1962).[2] It's a procedure which incorporates combination of hard and soft tissue reduction with or without orthodontic tooth exposure.

According to the definition of the American Academy of Periodontology, CL is "a surgical procedure designed to increase the extent of the supragingival tooth structure for restorative or esthetic purposes by apically positioning the gingival margin, removing supporting bone or both".[3,4]

CL is one of the foremost common surgical procedures in periodontal practice. A recent American Academy of Periodontology survey reported that approximately 10% of all periodontal surgical procedures are performed so as to achieve gain in crown length.[5]

Many cases might not be favorable for osseous resection surgery, especially anterior teeth where aesthetics may be a huge consideration. Bone resection results in supporting tissue loss for that tooth and the adjacent teeth, which causes interdental and marginal gingiva recession.[6,7] Orthodontic extrusion, with or without circumferential supracrestal fibrotomy, can overcome these disadvantages. Nevertheless, orthodontic extrusion is more complicated than crown lengthening by surgery because of the frequency of dental visits, long treatment time, high cost and relapse tendency with repeated fibrotomy.[7,8] Therefore, minimally traumatic controlled surgical extrusion is suggested for clinical crown lengthening to achieve highly successful outcomes.[8]

Indications

The indications for crown lengthening can be sub divided into three categories, these are:

- **Prosthetic**
  - Increase crown length
  - Produce ferrule effect
  - Relocate margins of restorations that are impinging on biological width
- **Asthetic**
  - Altered passive eruption
  - Gummy smile
  - Short teeth
  - Uneven gingival contour

- **Restorative**
- Restoration of subgingival caries
- To access perforations in the coronal third of the root
- Cervical root resorption

Classification of Aesthetic Crown Lengthening[9]

CLASSIFICATION	CHARACTERISTICS	ADVANTAGES	DISADVANTAGES
TYPE I	Sufficient soft tissue allows gingival exposure of the tooth without exposure of the alveolar crest and violation of the biologic width.	May be performed by the restorative dentist. Provisional restorations of the desired length may be placed Immediately	
TYPE II	Sufficient soft tissue allows gingival excision without exposure of the alveolar crest but in violation of the biologic width.	Will tolerate a temporary violation of the biologic width. Allows staging of the gingivectomy and osseous contouring procedures. Provisional restorations of the desired length may be placed immediately.	Requires osseous contouring. May require a surgical referral.
TYPE III	Gingival excision to the desired clinical crown length will expose the alveolar crest.	Staging of the procedures and alternative treatment sequence may minimize display of exposed subgingival structures. Provisional restorations of desired length may be placed at second stage gingivectomy.	Requires osseous contouring. May require a surgical referral. Limited flexibility.
TYPE IV	Gingival excision will result in inadequate band of attached gingival		Limited surgical options. No flexibility. A staged approach is not advantageous. May require a surgical referral.

Sequence of treatment (Allen 1993)[10]
Clinical and radiographic evaluation:
1) Caries control
2) Removal of defective restorations
3) Placement of provisional restorations
a) Control of inflammation
b) Better assessment of crown lengthening required
c) Improved surgical access, especially interproximally
d) Enhanced predictability of margin placement postsugically
4) Endodontic therapy:
a) Precede surgery
b) If not possible, completion is 4 to 6 weeks postsurgerically
5) Control of gingival inflammation
a) Plaque control
b) Scaling and root planing
6) Re-evaluation for
a) Orthodontic therapy
b) Surgical therapy
7) Surgery

Pre-surgical Analysis
Smulker and Chibi (1997)[11] recommended the following presurgical clinical analysis prior to crown lengthening procedures:
1. Determine the finish line prior to surgery
2. If non determinable, it should be anticipated

3. Transcrevicular circumferential probing prior to surgery is performed for establishing the biologic width (bone sounding)
a. Surgical site
b. Contralateral site
4. The biologic width requirements will determine the amount of alveolar bone removal
5. The combination of biologic width and prosthetic requirements determine the total amount of tooth structure necessary for exposure
6. Tooth structuretopography, anatomy, and curvature are analysed for determining
a. Osseous scallop
b. Gingival form

Treatment Modalities
1. External bevel gingivectomy
a. Scalpel
b. Laser
c. Electrocautery
d. Chemosurgery
e. Cryosurgery
2. Internal bevel gingivectomy
3. Apically displaced flap with or without bone resection
4. Combined technique (Surgical and Orthodontic)

1. External bevel gingivectomy
a. Scalpel:

External bevel gingivectomy with scalpel is done in cases where there's sufficient sulcular depth and keratinized tissue so that the incision doesn't violate the biologic width and with low bony contours, where osseous resection is not required. This technique was described by Goldman in 1951.[12]
Contraindications:[13]
1-When crown lengthening requires bone surgery or examination of the bone shape and morphology. 2-Situations in which the bottom of the pocket is apical to the mucogingival junction. 3-Esthetic considerations, particularly in the anterior maxilla.
Merits:
1-Flap elevation is not required. 2-Easy to perform. 3-Easy to learn and practice.
Demerits:
1-Raw surface is left exposed. 2-More post-operative pain. 3-Delayed healing

b. Laser:[13]
It is used in cases with low bony contours, where osseous resection is not required. The soft tissue lasers most often used in dentistry are the carbon dioxide (CO2) and the Nd:YAG, Argon with wavelengths of 10,600nm and 1064nm, respectively. These must be combined with other sorts of visible lasers for the beam to be seen and aimed.
Merits:[14]
1-Dry and bloodless field to work. 2- Less time consumed. 3- Instant sterilization of the area, therefore decreasing the chances of bacteremia. 4- Prompt healing. 5- Minimal post-operative swelling and scarring. 6-Less post-operative pain.
Demerits:[14]
1-Expensive appliance. 2- Laser safety precautions must be followed.
c. Electrocautery:
This method was given by Flocken in 1980.[15] It is also called as surgical diathermy. It is defined as division of tissue by high frequency electrical current applied locally with a metal instrument or needle. It is used at high frequency current of 1.5-7.5 million cycles per second.
Three classes of electrodes used:
- Single wire electrodes for incising and excising.
- Loop electrodes for planing tissues.
- Heavy bulkier electrodes for coagulation procedures.

Merits:[16,17]
1-It permits adequate contouring of the tissue. 2- It controls haemorrhage.
Demerits:[16,18,19,20,21]

1-If it touches the bone, irreparable damage may result. 2- If electrode touches the root, areas of cementum burn are produced.

d. Chemosurgery:
Agent used: Potassium hydroxide[22], 5% paraformaldehyde [23]
Merits:[24]
1-Elimination of tissue done without anaesthesia.2- Elimination of tissue without pain.3- Elimination of tissue without bleeding.

Demerits [13,24]
1-Paraformaldehyde is limited in action about 1mm in depth. 2- Repeating of packing is required. 3- Leaving a pack in place for longer period will delay healing. 4- Necrosis of bone can occur if pack kept below the bone margin. 5-Abscess formation may occur. 6- Depth of action cannot be controlled. 7-Gingival remodelling cannot be accomplished effectively. 8-Gingival epithelization and re-formation of the junctional epithelium and reestablishment of the alveolar crest fiber system occur more slowly in chemically treated gingival wounds than in those produced by a scalpel.
e. Cryosurgery[25]:
Cryosurgery is the use of utmost cold in surgery to destroy abnormal or diseased tissue; thus, it is the surgical application of cryoablation.
Merits:
1-Bloodless field of work. 2-Can be used in vascular gingival enlargements. 3- No pain because of blockage of neural transmission. 4- No secondary infection. 5- Economical
Demerits:
1-Depth of action cannot be controlled. 2- Healing is delayed and painful, packs are required for longer periods.

2. Internal Bevel Gingivectomy With or Without Ostectomy (Undisplaced Flap)[26]
It is the procedure done in cases with both low and high bony contours which may or may not require osteoplasty and osteotomy.
Surgery without ostectomy
To perform this technique without creating a mucogingival complication, it should be determined that sufficient attached gingiva should remain after the incisions are made.
Surgery with ostectomy
It is the most common procedure used for the clinical crown lengthening. A mucoperiosteal flap is designed and raised along with osteotomy. Osteotomy is done to expose the required tooth length in a scalloped fashion to follow the desired contour of the overlying gingiva. The final bone level should be measured carefully in all locations around the tooth to be sure that the minimal dimension of three to five mm of tooth height has been achieved throughout the circumference of the tooth.
Merits:[27]
1-It removes the pocket lining. 2- It conserves the relatively uninvolved outer surface of the gingiva. 3- It produces a sharp pointy, thin flap margin for adaptation to the bone-tooth junction. 4- No raw surface is left exposed. 5- Healing by primary intention.
Demerits:[28]
May cause crestal bone loss if flap elevation is done.

3. Apically Displaced Flap with or Without Osseous Resection:
One of the first authors to describe a technique for the preservation of the gingiva following surgery was Nabers (1954).[29] In 1962 Friedman[30] proposed the term apically repositioned flap to more appropriately describe the surgical technique introduced by Nabers.
The apically positioned flap technique with bone recontouring (resection) could also be used to expose sound tooth structure. As a general rule, at minimum 4 mm of sound tooth structure must be exposed at time of surgery. In some cases, osseous reduction may not be required as in cases where bone level is low and insufficient attached gingiva is present.

During healing the supracrestal soft tissues will proliferate coronally to cover 2-3 mm of the root[31,32] thereby leaving only 1-2 mm of supragingivally located sound tooth structure and provide widening of zone of attached gingiva, for crown lengthening in reduced attached gingiva.

Indication:[33]
a) In sites where there is insufficient gingiva for reduction, high bony contour and insufficient attached gingiva.

b) Crown lengthening of multiple teeth in a quadrant or sextant of the dentition.

Contraindication:

Surgical crown lengthening of single teeth within the esthetic zone.

Merits:[30]

1-Widened zone of attached gingiva. 2- Close approximation of flap causes healing by primary intention. 3-The bone afforded has maximum coverage by the viable tissue of the flap thus preventing macroscopic sequestration and probably minimizing permanent loss of alveolar crest. 4- The postoperative amount of gingiva may be controlled precisely. 5- The retention of the mucogingival complex and shifting it apically enables the surgeon to create a functionally adequate investing unit, to deepen a shallow vestibule and reposition frena utilizing mature tissue.

Demerits:[30]

1-This procedure cannot be done in single tooth in esthetic zone where irregularity of marginal gingiva may be produced. 2- The apically shift of the soft tissue & subsequent exposure of root surfaces may cause esthetic and root sensitivity problems.

4. Rapid Orthodontic Extrusion:

Orthodontic extrusion is also known as forced eruption therapy (FET). FET for the treatment of isolated non-restorable teeth as described by Ingber and is based on the biologic premise that orthodontically erupted root segments are accompanied coronally by their associated gingiva and supporting structures.[34] Reitan and others have demonstrated histologically and clinically that eruptive tooth movements result in a stretching of the gingival and periodontal fibers, which produces a coronal shift of gingiva and bone.[35,36]

Circumferential supracrestal fiberotomy (CSF) is severing of the connective tissue attachment (via fiberotomy) apparently eliminating the transmission of tensile forces to the periodontium and preventing osseous remodeling at a level coronal to the remaining intact fiber attachment." Pontoriero et al have demonstrated clinically that where principal fibers were severed during FET, bone did not accompany the tooth in a coronal direction, and where fiberotomy wasn't performed, bone did remodel coronally after a 3 to 6 month period of time.[37] CSF prevents reversal of the osseous architecture and the relapse of extruded teeth. However, even with fiberotomy the coronal shift of the gingiva was not predictably stable.[38,39] To assure an esthetic gingival margin position following rapid extrusion with fiberotomy therapy, a gingival correction procedure may be necessary.

After proper dentogingival relationships have been cultivated, the new tooth position should be stabilized to allow osseous remodeling.[34,40]

Indications:

Rapid orthodontic extrusion with CSF is done in cases with sufficient root crown ratio with sufficient attached gingiva to increase the clinical crown length.[41]

Contraindications[41,42]

1-Short root length ratio and poor root form, which result in inadequate crown/ root ratio following extrusion. 2-Should not be performed in tooth associated with periodontal defect.

Merits:

Only supracrestal fiberotomy is required.

Demerits:

May cause root resorption, ankylosis or mobility.

FET can be done by various methods such as: post placement into the RCT treated tooth (**Fig 1,2)**, wire attachment by composite and e chain (**Fig 3**), Orthodontic extrusion with button and e chain or elastic (**Fig 4**).

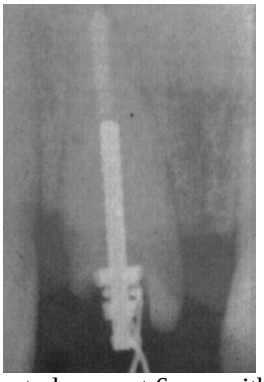

Fig 1- Radiograph demonstrating post placement 6 mm within alveolar bone prior to eruption.

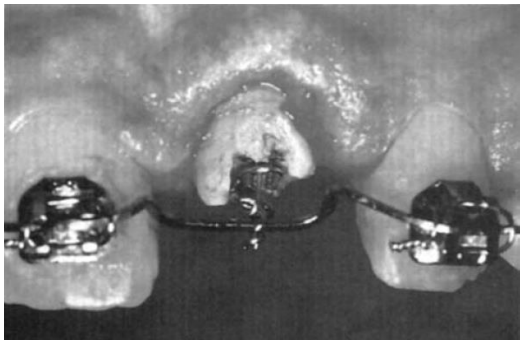

Fig 2- 2 mm distance between the serated post and 0.022 X 0.025 stainless steel rectangular wire.

Fig 3- Orthodontic extrusion with wire attachment by composite and e chain

Fig 4- Orthodontic extrusion with button and e chain or elastic

5. Combined Technique (Surgical and Orthodontic):

Orthodontic extrusion with slow forces or forced eruption therapy provides the extrusion of tooth along with the tissue and bony attachment. With light forces (30g), tensions of the periodontal fibers are delivered to the bone and coronal migration of periodontium occurs.[41] Combination of surgical and orthodontic extrusion help to increase bony attachment and width of attached gingiva.

In this procedure firstly FET is done followed by surgical excision of soft tissue for tooth exposure.

Indications:

Cases with less width of attached gingiva.

Contraindications[31,41]

1- Short root length ratio and poor root form, which result in inadequate crown/ root ratio following extrusion.

2- Should not be performed in tooth associated with periodontal defect.
Merits[41]
1-With light forces (30g), tensions of the periodontal fibers are delivered to the bone. 2- Coronal migration of periodontium occurs with the extrusion of tooth.
Demerits:
Long time duration.

Prosthesis Management
The first and foremost thing to consider during any surgical or prosthetic procedure is to consider biological width.

Biologic width violation
The dimensions of the space that the healthy gingival tissue occupies above the alveolar bone is called biologic width.[43] It can be violated by placement of a deep subgingival restoration which develops inflammatory changes.[44]
There are three options for margin placement:

- Supragingival- Placement of finish line of prosthesis above gingival margin. It is applied in non-esthetic areas due to the marked contrast in color and opacity of traditional restorative materials against the tooth.
- Equigingival- Placement of finish line of prosthesis at gingival margin. Both supragingival and equigingival margins are well tolerated from a periodontal viewpoint.
- Subgingival- Placement of finish line of prosthesis below gingival margin. It is considered because of caries or tooth deficiencies, and/ or to mask the tooth/restoration interface.

It was suggested that a minimum of 3 mm space was required from the restorative margin to the alveolar crest to permit adequate healing and restoration of the tooth.[45] It was also suggested that subgingival margin extension to 0.5mm is to be done because it is impossible for the clinician to detect where the sulcular epithelium ends, and the junctional epithelium begins.[46]

Margin placement — Rules[47]

- Sulcus probes 1.5 mm or less- Restorative margin placed 0.5 mm below the gingival tissue crest.
- Sulcus probes >1.5 mm and upto 2mm- Restorative margin placed in half the depth of the sulcus.
- Sulcus >2 mm- Gingivectomy could be performed to increase the length of tooth and creating a 1.5 mm sulcus depth. After this the patient can be treated as per rule 1.

Kois[48] proposed three categories of biologic width based on the total dimension of attachment and the sulcus depth following bone sounding measurements, namely: **(Fig 5)**

- Normal Crest
- High Crest and
- Low Crest

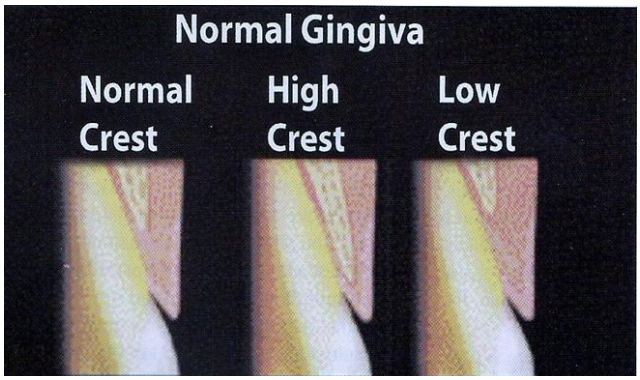

Fig 5- Categories of biologic width based on the total dimension of attachment and the sulcus depth

Prosthesis Management
Three procedures can be adopted based on the time point when the teeth are prepared and on the position of the margins of the prosthesis with respect to the gingival margin[49]: **(Fig 6)**

a) Intra-operative tooth preparation and relining of the provisional restoration.

b) Early tooth preparation and relining of the provisional restoration.
c) Delayed tooth preparation and relining of the provisional restoration.

a) Intra-operative tooth preparation and relining of the provisional restoration:
In this approach, tooth preparation is administered during surgery, after ostectomy and osteoplasty, usually with the utilization of diamond burs. Abutments are prepared with knife- edge margins at the bone crest level.

b) Early tooth preparation and relining of the provisional restoration:
In this approach, tooth preparation occurs after 3 weeks from the surgery.[50] The rationale for this approach is to manage the provisional prosthetic steps after the initial healing has taken place and restoration of the connective tissue attachment.

c) Delayed tooth preparation and relining of the provisional restoration:
This approach is predicated on the concept of not interfering with healing of the soft tissues.[51] After the CL procedure, the margins of the provisional restoration are maintained at the presurgical level until soft-tissue stability is achieved (9–12 months). At this point, the final abutment preparation is performed and the final prosthesis is delivered.

Wound Healing

After the surgical procedure ends, the healing phase begins. Research has shown that when the clinician creates an apically positioned flap with an osseous resection procedure, the biological width reestablishes itself at an apical level.[52] It has also been observed that a postoperative vertical gain or rebound in supracrestal soft tissues occurs that averages 3 mm, if the margin of the flap is positioned at the level of the osseous crest.[53,54] If the flap margin is placed at a level more coronal to the newly established osseous crest, less vertical gain or rebound in supracrestal soft tissues is observed.[55] Lanning and colleagues[56] demonstrated that coronal advancement of the healing tissues from the osseous crest averages 3 mm by three months' time after surgery. They also resulted with no further significant changes in the vertical position of the free gingival margin after six months of surgery. Bragger and colleagues[57] also noted that during a six-month healing period after crown lengthening, periodontal tissues were stable, with minimal changes in the level of the gingival margin. From these findings, one can conclude that regarding final prosthetic treatment in the esthetic zone, the waiting period after a crown-lengthening procedure should be six months.

New Advances For Ease Of Treatment

Contemporary periodontal therapy also encompasses aesthetic treatment where needs are frequently associated with changes in tooth size, shape, proportion, and balance that can negatively affect smile appearance.[58]

There are myriad of techniques that have evolved over several decades to treat this situation. One such technique is introduced by Stephen J Chu in 2007.[59] He introduced CL probes which help and ease the procedure of CL. **(Fig 7)**

He invented three categories of gauges. Proportion gauge which includes T-Bar gauge and In-Line gauge. The Proportion Gauge is a single handle, double-ended instrument with "T-Bar" and "In-Line" tips screwed into the handle at opposing ends. The T-Bar gauge is employed to measure non-crowded anterior dentition and the In-Line for a crowded dentition. The vertical arm represents length and horizontal arm represents width.

Another is Crown Lengthening Gauge, it also includes two tips first "Biologic Perio Gauge (BLPG) Tip" designed to measure the midfacial length of the anticipated restored clinical crown and the length of the biologic crown simultaneously during surgical crown lengthening. Another is papilla tip which is used for measurement of the clinical height of papilla.

The advantage of the CL Gauge over such conventional means are precision during the procedure.
The last is bone sounding gauge. The Sounding Gauge is used in aesthetic periodontal crown-lengthening procedures to determine the level of the bone crest prior to flap reflection.

II. Conclusion

The key to a successful outcome with long term future stability is the establishment of an accurate diagnosis and subsequent development of a comprehensive treatment plan. There are various treatment options for teeth mutilated at the gingival or subgingival levels. Intraorally, important considerations include condition and dimensions of the teeth; thickness, width, position and contour of gingival tissue; height of the anatomic crowns versus height of the clinical crowns; root anatomy; and topography of the alveolar bone. Often a combination of orthodontic extrusion and surgical crown lengthening can be employed to attenuate the

necessity for resective therapy on adjacent teeth, improve the crown–root ratio and facilitate a more aesthetic outcome. While planning, full periodontal condition should be evaluated to disclose all possible treatment options to the patient. In cases involving the possibility of a negative esthetic outcome, compromise to the support of the dentition involved in the surgical procedure or both, extraction and implant therapy or conventional prosthetic therapy may be a better solution.

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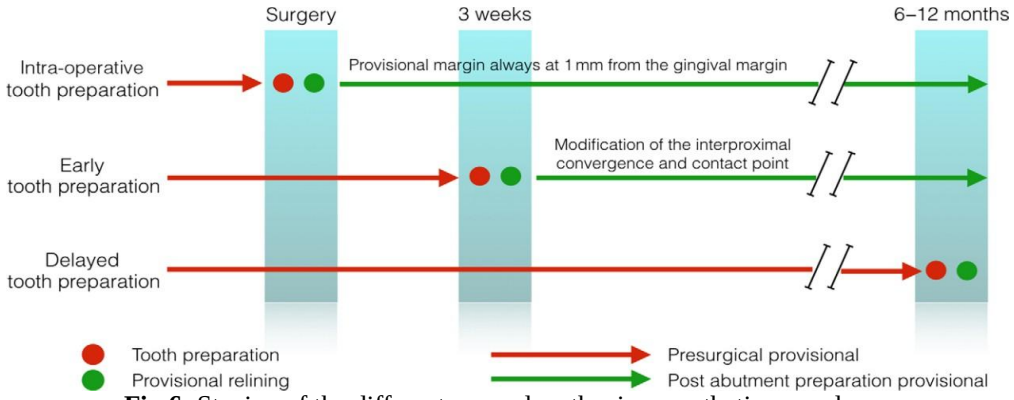

Fig 6- Staging of the different crown lengthening prosthetic procedures

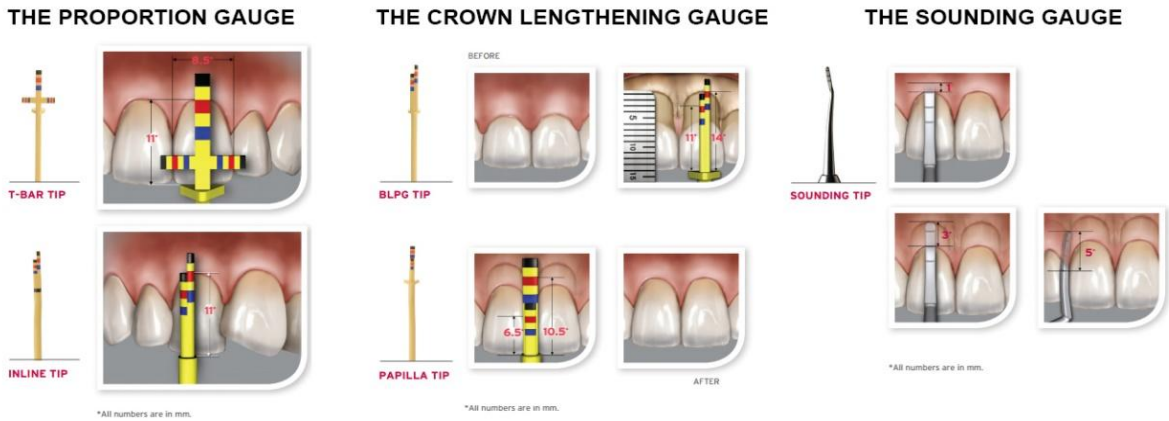

Fig 7- Chu's CL probes

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