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PREFACE

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Contents

Chapter 1

USE OF GROWTH FACTORS AND BONE GRAFTS IN PERIODONTOLOGY

Alper KIZILDAĞ[1]

The aim of the regenerative therapy is the restoration the function and structure of deteriorate periodontal tissues. In dentistry, the regenerative therapy techniques involve soft tissue graft, bone grafting materials (autogenous, human, animal and synthetic sources), tooth graft materials, biologic molecules, autogenous cells and growth factors (Bartold & ark., 2000, Greenwell, 2001).

BONE GRAFTS

Bone grafts are placeholder materials and stimulate the bone formation. Ideal bone grafts should have some features such as have not antigenic properties, increasing the revascularization, stimulating the osteoinduction, osteoconduction and osteogenesis. Bone grafts are classified as four groups: autograft, allograft, xenogreft and alloplast graft.

Autogenous Graft

A type of graft transplanted from one place to another in the same individual is termed autogenous graft. Autogenous grafts can obtained from the iliac, tibia, femur, costa, calvarium in extraorally and symphysis, the anterior edge of the ramus, the region of maxillary tubular, the corpus, the zygomatic bone, the coronoid protrusion and the alveolar crest in intraorally. Autogenous graft, which has osteoinductive, osteoconductive, and osteogenic properties, is considered gold standart. Use of the autogenous grafts can decrease the transmission of infectious diseases. However, postoperative pain, donor site complications, creating the second wound site, limited availability and problem of bone resorption are accepted disadvantages for autogenous grafts (Jemt & Lekholm, 2003, Fellah & ark., 2008).

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Allograft

Grafts prepared from the same species but different individuals are called allografts. Allografts are obtained from living people or cadaver. They are used in three forms; fresh frozen bone, freze-dried bone and demineralized freeze-dried bone. Allograft has several advantages compared with autogenous graft such as absence of second wound site for patient, obtaining the adequate amount of graft in large bone losses and providing the ease of use. However, biologic materials in grafts which are necessary for new bone regeneration, are reduced by cleansing and disinfecting procedures, and also these grafts have the risk of disease transmission (Murugan ark., 2009). In addition, allografts have several disadvantages involving the risk of infection and inflammation, lead to immune response and additional cost for the patient (Dragoo & Sullivan, 1973, Goldberg &Stevenson, 1993, Lane, Tomin & Bostrom, 1999).

Xenograft

Obtained from different species graft is termed xenograft. Xenografts are an alternative to autogenous bone grafts such as allografts. Bovine graft materials are predominantly used in this group. Certain methods are applied to prevent the immun reaction and antigenicity including decoction, freze-dried, dry heating or radiation. Xenografts have several problems involving high osteoconductive and low osteoinductive properties, rapid bone resorption after applying, and late or incomplete bone integration (Aghaloo, Moy & Freymiller, 2002).

Alloplastic Graft

Alloplastic grafts are completely produced synthetically and used an alternative to other graft materials. They are consist of hydroxyapatite, bioactive glass, or calcium carbonate. Advantages of the use of alloplastic grafts are unlimited availability and lack of immune response. However, these graft materials do not have any osteoinductive properties and they stimulate new bone formation limitedly. Also, the healing was commonly characterized with a long junctional epithelium in bony defects (Mellonig, Valderrama & Cochran, 2010, Dumitrescu, 2011, Horvath & ark., 2013).

TOOTH GRAFT

Tooth hard structure comprises of enamel, dentin and cementum. Especially, chemical composition of dentin consist of inorganic and organic structure like bone (Yoshida & ark., 2008, Bath-Balogh & Fehrenbach, 2014). Dentin can stimulate the osteogenic activity and bone formation because of its contain growth factors (Qian & Bhatnagar 1996). In addition, cementum includes growth factors similar to dentin (Schmidt-Schultz & Schultz, 2005). Over the past decade, tooth graft materials are considered as alternative graft material instead of bone grafts (Kim & ark., 2010, Kim & ark., 2013). Several studies suggested that dentin must be demineralized before using as graft material. Because, dentin tubules expose by demineralization procedures and hence, proteins, which contain growth factors, are secreted (Li & ark., 2011). However, long time is necessary for demineralization procedures and for this reason using of demineralization dentin matrix is difficult in clinically, Besides, acid exposure during demineralization may reduce the release of growth factors. (Pietrzak & ark., 2011)

Recent years, autogenous mineralized tooth graft has been used to eliminate the disadvantages of demineralized dentin. These grafts have no risk of disease transmission, are not necessary additional chemical procedures during preparation, and it could be used combine with membrane such as platelet rich fibrin. Therefore, several studies suggested that autogenous mineralized tooth graft could be used alternative graft material in bone surgery (Pohl & ark., 2016).

GROWTH FACTORS

Growth factors are natural polpeptidic molecules and they play critical role on tissue healing by regulate the cellular events including proliferation, chemotaxis and differentiation of cells. Various growth factors are defined related with periodontal tissue healing such as platelet-derived growth factor (PDGF), insulin-like growth factors (IGF), fibroblast growth factors (FGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF) and bone morphogenetic proteins (BMPs). These growth factors have certain properties on tissue healing.

Platelet-Derived Growth Factor

PDGF family comprises of four groups (A, B, C and D) and they appear in a dimeric form (AA, BB, CC, DD or AB). PDGF-A especially influences early stages of healing, however, PDGF-B play a role late stage of wound healing. PDGF are released primarily from the platelet α-granules. Chemotaxis of several cell involving monocytes, gingival fibroblasts and periodontal ligament (PDL) cells types, are arranged by PDGF (Kaigler & ark., 2011). Thus, PDGF improves tissue healing by stimulates the cellular events. Also, PDGF enhances the bone formation and bone density in animal model (Stavropoulos & Wikesjo, 2012). Studies showed that PDGF accelerates the regeneration of periodontal intrabony and periodontal furcation defects (Camelo & ark., 2003, Nevins & ark., 2005).

Also it has been reported that PDGF can use with graft materials and it increases the effect of these graft materials on tissue healing (Nevins & ark., 2003).

Bone Morphogenetic Proteins

BMPs are member of TGF superfamily and produced by osteoblasts and osteocytes cells. They induce the bone healing by differentiate the pluripotent stem cells to cartilage or bone-forming cells (Foster & Somerman, 2005, Ikada, 2006). BMPs are the only growth factors known to be capable of initiating bone formation outside the skeletal areas because they transform the soft tissue cells into bone produced cells (Ripamonti & Reddi, 1994, Lee, 1997). BMP family comprises of more than 20 members, such as BMP-2, BMP-3, BMP-7 and GDF-5. However BMP-2 has more regenerative potential on periodontal tissues compared with other BMPs (Yokota & ark., 2001).

Fibroblast Growth Factors

FGF is a member of a large family of polypeptides and regulates the growth and differentiation of cells (Davidson & ark., 2005). FGF-1 (also known acidic FGF) and FGF-2 (also known basic FGF) are most known forms of FGF. FGF is produced primarly PDL fibroblast and endothelial cells and it stimulates the chemotaxis, attachment and proliferation of PDL and endothelial cells. FGF increases the bone repairing and bone formation. Also, FGF induces the vascularization and this property is valuable to bone healing. FGF play an important role on wound healing by stimulates the growing of immature PDL cells. In animal study, FGF-2 applied with carrier gelatin in furcation defects and reported that FGF-2 enhanced the new PDL, cementum and bone regeneration (Murakami & ark., 2003). Furthermore, FGF-2 stimulates osteocalcin production and matrix mineralization in mature cells (Shimabukuro & ark., 2005).

Insulin-like Growth Factors

IGF, most common growth factors in bone matrix, is a single-chain protein. IGF effects the metabolic activity and growing of several tissues and cells (Schliephake, 2002). IGF consists of two forms: IGF-1 and IGF-2. However, IGF-2 has not any effect on the bone formation and the activity of PDL and gingival fibroblasts.

IGF-1 is produced by various tissues and cells including liver, osteoblasts, platelets, macrophage, monocyte, fibroblast and keratinocyte. IGF-1 provides the proliferation of osteoblast and differentiation of osteoblasts to osteocytes and induces the synthesis of Tip I collagen (Baylink, Finkelman & Mohan, 1993). IGF-1 increases the expression and proliferation of bone sialoprotein gene, however it does not affect the expression of osteopontin and osteocalcin gene. In addition, IGF-1 elevates the proliferation and chemotaxis of PDL cells depending on dose and time (Lind, 1996).

Vascular Endothelial Growth Factors

VEGF is secreted by mesenchymal stem cells and plays a role on angiogenesis and osteogenesis (Quarto & Longaker 2006). VEGF improves the proliferation of endothelial cells and secretion, migration and chemotaxis of proteolytic enzymes. VEGF comprises of five isoform. VEGF has a synergistic angiogenic effect with FGF and stimulates the release of FGF. VEGF enhances the proliferation, migration and stimulation of endothelial, fibroblasts and inflammatory cells which are effective cells on wound healing (Distler & ark., 2002).

Transforming Growth Factor-Beta

TGF-β is a member of large TGF family and consists of three forms in mammalians: TGF-β1, TGF-β2 ve TGF-β3. TGF-β is released from platelets, macrophages and bone. TGF-β stimulates the myofibroblastic differentiation and regulates the extracellular matrix deposition. TGF-β increases the matrix synthesis of cells and induces the proliferation and chemotaxis of bone cells. One of the most significant roles of TGF-β is ensures the differentiation of osteoblasts and increases the Tip I collagen. TGF-β prevents the destruction of connective tissue matrix by decreasing the synthesis of matrix metalloproteinases and plasminogen activators. Also TGF-β increases the proliferation of PDL fibroblasts and provides the better binding of these fibroblast cells to root surfaces (Okuda & ark., 2003).

Platelets

Recently, tissue engineering studies focused the use of scaffold structure which supporting the newly formed tissues, along with stem cells and growth factors. However, these stem cells and growth factors are very expensive for the patients. Therefore, platelets as source of growth factors are widely used in regenerative dentistry. Platelets are formed by the megakaryocytes and they are disc-shaped and seedless structures. Life spans are 8-10 days. Activation of platelets are neccessary to initation of hemostasis in coagulation stage. Platelet degranulation also causes cell migration and proliferation by release of cytokines in initial stage of healing. Platelets contain several proteins which as follows: α granules, fibrinogen, fibronectin and thromboglobulin. In addition, platelets include important growth factors and these growth factors promote the cell mitosis, increase the collagen production, initiate the vascular growth and induce the cell differentiation. At first, platelet concentrates were performed as fibrin glue to utilized growth factors and enhance healing (Dohan Ehrenfest & ark., 2014). Then, platelet rich plasma (PRP) which is a first generation platelet concentrates, was developed (Marx, 2001). PRP consists of approximately %95 platelets and increases the wound healing by secretes the growth factors. Besides, plasma rich in growth factors (PRGF) was developed by using anticoagulants (Anitua, 1999). Although these platelet concentrates increase the growth factors level in application area, they are several disadvantages such as high cost and addition of the thrombin or anticoagulants. In addition, it has been reported that PRP releases the growth factors at early stage (Kobayashi & ark., 2016). To eliminate the these problems, Choukroun et al. developed the second generation platelet concentrate (Choukroun & ark., 2001).

PLATELET-RICH FIBRIN

Platelet-rich fibrin (PRF) is a second generation platelet concentrate and has several advantages such as easy of preparation and application compared with PRP and PRGF. Also bovine thrombin or anticoagulants are not required to preparation of PRF (Choukroun & ark., 2001). PRF is formed by natural and gradual polymerization during centrifugation. PRF consist of fibrin network and this fibrin network holds the stem cells in circulation (Dohan & ark., 2006). Additionally, it has been reported that the molecules of PRF in fibrin networks can release during long period (Dohan & ark., 2006). The benefits of PRF listed during bone grafting which as follows:

1. Blood clot enhances the mechanic stabilization of the graft particles.
2. Fibrin network improves the neo-angiogenesis, vascularization and migration of endothelial cells.
3. As the fibrin matrix begins to be resorbed, the cytokines in platelets are gradually released and ensured a permanent healing process.
4. Cytokines and leukocytes control the regulation of infectious and inflammatory events in graft materials.

The important feature of PRF is that platelets in PRF contain a large amount of growth factors which are natural polypeptide hormones (Davis & ark., 2014). Growth factors accelerate the tissue healing by increasing the proliferation and differentiation of cells and synthesis of extracellular matrix. PRF dissolves slowly and so it remains long period in tissue than PRP. PRP secretes growth factors especially within first days after application, however, PRF releases its growth factors over a period of 2 to 4 weeks (Kobayashi & ark., 2016, Arabaci & ark., 2017).

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Chapter 2

ELASTICS IN ORTHODONTICS

Ufuk OK[1]

1. INTRODUCTION

Elastics and elastomeric materials are used in several states of orthodontic treatment. With good patient cooperation, they make it possible for the physician to fix both anteroposterior and vertical direction anomalies.

Elastics were discussed at a dental conference for the first time in 1893 by Calvin S., but their first clinical usage was carried out by Henry A. Baker for applying intermaxillary force in a class II case [1].

Natural latex elastics are used usually in the Begg's method for intermaxillary fixation and intermaxillary force application purposes [2].

Chain-formed elastomers are usually included in the Edgewise technique. Their most important function in this technique is moving the tooth or teeth along the arch wire. There are several types of usage for elastics (Figure 1).

Figure 1. Types of Using Elastics

2. EXAMINING ELASTIC FORCES

The force that is applied by elastics on the tooth or teeth may vary based on the dimensions of the elastics. Stress creation depends on the region they are applied, distribution on the periodontal ligament, direction, length, diameter, the contour of the root of the tooth, alveolar process, rotation of the tooth, age of the patient and patient cooperation [3].

Elastic forces may be easily combined by anchorage flexions where class I elastic traction will be applied. However, the most important issue to be consid-

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ered in such combined usage is the protection of the anchorage. This is because, as a result of the retractive and intrusive forces to be applied, these may lead to the movement of the maxillary molars towards the opposite of what is desired or loss of anchorage in the maxillary molars. Elastic forces are applied on the vertical direction to the incisor teeth. This brings the incisors to supraocclusion or reinforces the already existing supraocclusion. With the arch wire force that is applied on the mandibular molar teeth, the crown has a tendency to move towards the distal, while the root has a tendency towards the medial. In order to prevent such a case, the forward pulling function of the elastic force is utilized. If there is compatibility between anchorage flexion and the elastic force, the tooth will be extruded. With week forces to be applied with elastics, the crowns of the anterior teeth will move towards the labial or the palatinal. However, this will partly carry the molar teeth towards the anterior: (with parallel motion) if the elastic forces are applied on the molars and the anterior teeth with the same magnitude but in opposite directions, the resistance values will not be equal. Therefore, crown tipping will be fast, but parallel movement will be slow [4,5].

3. FORCE DEGRADATION

Latex elastics will experience more degradation in comparison to plastic elastomers in a 21-day flexing period. Elastomeric chains will lose 50-70% of their force in the 1st day of application. In the 3rd week after the application, they will be able to apply only 30% or 40% of the original force on the tooth or teeth [6,7].

4. CLASSIFICATION OF ELASTICS

4.1. Based on material

4.1.1. Latex elastics

This type of elastics that are made out of natural rubber (Figure 2) use either plant sources or artificial sources produced in the laboratory as their raw material. The source that is aimed to be obtained is 1-4 Polyisoprene.

Synthetic elastics

They are made out of polyurethane rubber (Figure 3). Clinically, they are used for ligation of elastics.

Figure 2. Packaged ready-to-use form of latex elastics

Figure 3. Packaged form of synthetic elastics ready for clinical use

4.2. Based on usage

4.2.1. Intraoral

They play the major role in fixed orthodontic treatment. There are 3 forms of application. First of all, in case of any centric occlusion disorder, they allow sagittal regulation by connecting maxillary dentition and mandibular dentition (Figure 4). Secondly, they are used in modifying crossbites and mid-line deviations. Thirdly and finally, they are used in the vertical regulation of the occlusion at the end of orthodontic treatment [7].

Figure 4. Example of intraoral usage (sagittal)

4.2.2. Extraoral

They are used alongside extraoral mechanical systems. They are used between cervical headgear and face-bow or between face-bow and high-pull headgear (Figure 5).

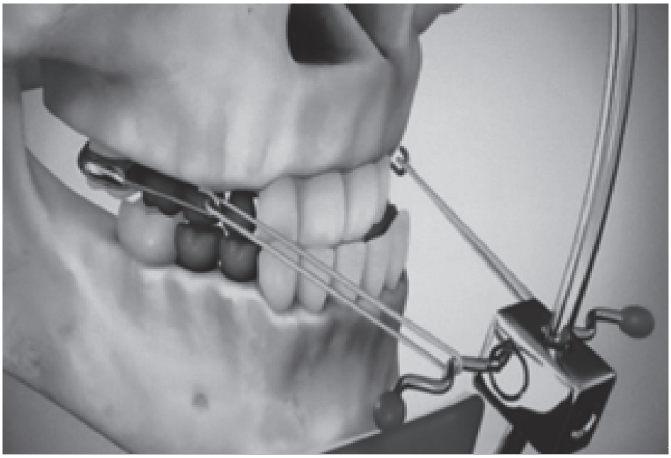

Figure 5. Example of extraoral usage

Class I elastics – horizontal elastics – intermaxillary elastics

They lie inside the maxillary or mandibular arch. They are used for purposes of filling gaps and partly opening the bite. The extend from the molar tube and the intramaxillary hook in the same arch (Figure 6). It is recommended to apply these with a force of 1½ - 2½ oz. in cases without tension and 2–4 oz. in cases with tension [8].

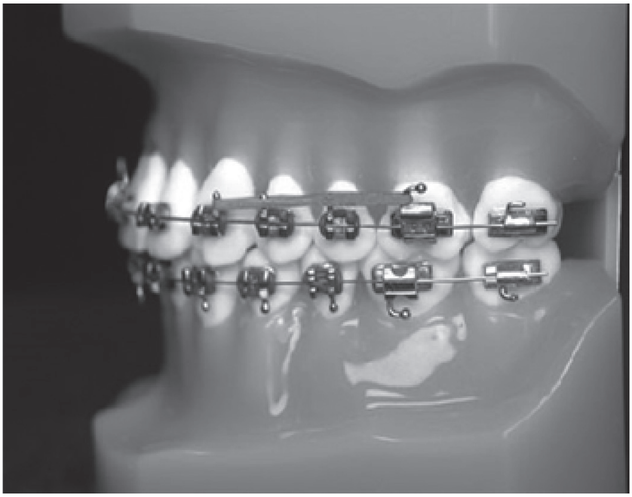

Figure 6. Example of horizontal usage

4.2.3. Class II elastics – intramaxillary elastics

They extend from the mandibular molar tooth on the same side to the intermaxillary hook on the maxillary teeth (Figure 7). While they show an effect in the anteroposterior direction, they help bringing class II molar status to class I molar status. It is recommended to apply these with a force of 1½ - 2½ oz. in cases without tension and 2–4 oz. in cases with tension [9].

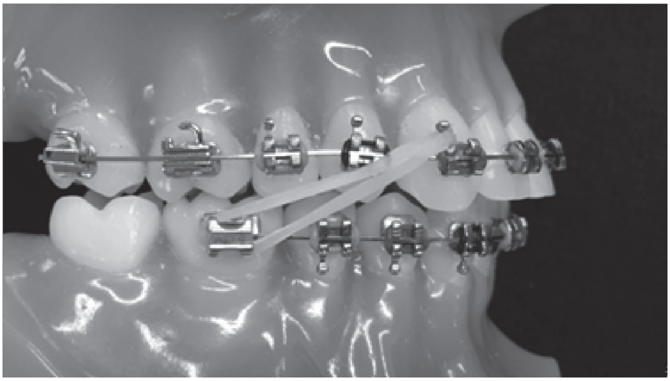

Figure 7. Example of intermaxillary elastics

4.2.4. Class III elastics

They work with a mechanism that is the complete opposite of class II elastics. They extend from the maxillary molar tooth to the intermaxillary hook on the mandibular tooth (Figure 8). They may be used to adjust the border occlusions of the anterior teeth in some class II cases. They induce extrusion in the upper posterior and anterior teeth and tipping towards the lingual in the lower teeth [10].

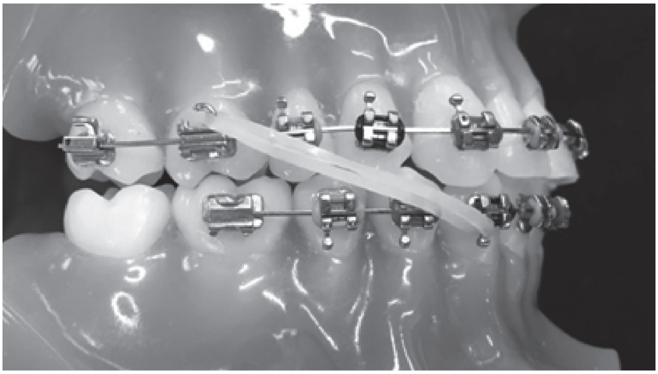

Figure 8. Example of class III elastics

Anterior elastics

They regulate the overbite of the incisor teeth. In treatments of closing openings up to 2 millimeters, they are used by extending from the mandibular lateral teeth to the maxillary lateral teeth or vice versa (Figure 9). It is recommended to use these following lingual straightening or in adjusting overbite and with a force of 1–2 oz. [10].

Figure 9. Example of using anterior elastics

Zig zag elastics

They are used in rotational adjustment in teeth with two cusps. They are applied from a two-cusp tooth towards a single-cusp tooth or from a two-cusp tooth to a molar tooth (Figure 10). However, they may also lead to unwanted molar movements. They are indicated in extrusion cases or in cases where the position is readily available. It is recommended to apply these with a force of 2–5 oz. [11].

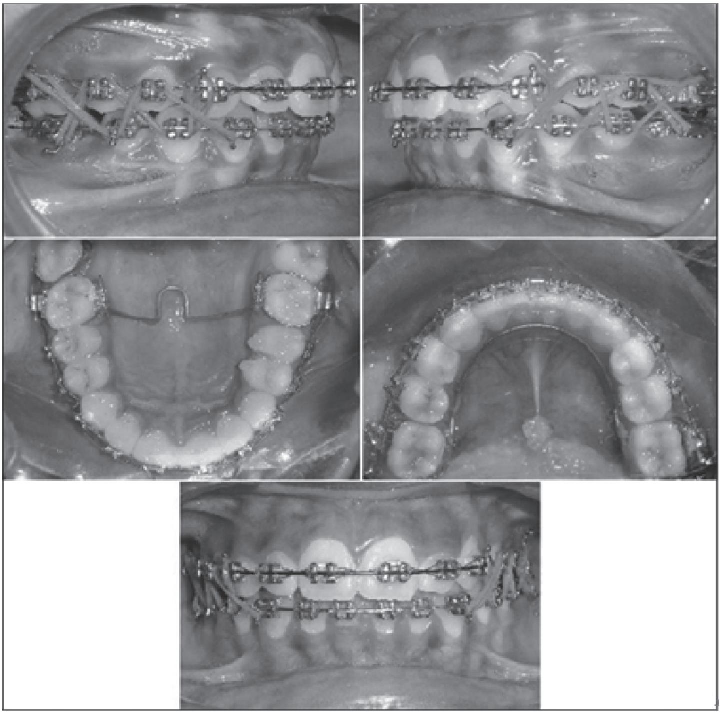

Figure 10. Example of using zig zag elastics

Crossbite elastics

They are indicated in unilateral or bilateral crossbite cases. They are used for the purpose of straightening or broadening the molar teeth that are bent towards the lingual. They are used by extension from the oral side of the lingualized tooth to the buccal face of the molar tooth on the same side (Figure 11). It is recommended to apply these with a force of 5–7 oz.

Figure 11. Example of using crossbite elastics

4.2.5. Elastics that go across the palatinal

They are used to fix the unwanted expansion of maxillary molar teeth. They lie between two opposite maxillary molar teeth in a way to cross their palatinal faces (Figure 12).

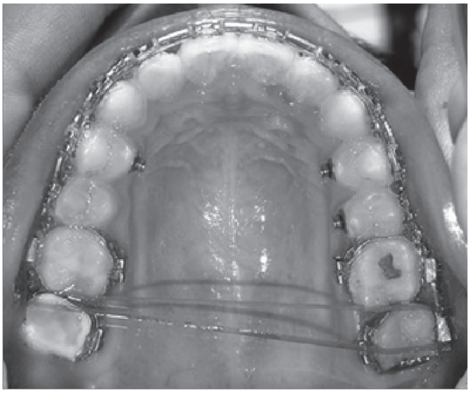

Figure 12. Example of using elastics that go across the palatinal

Diagonal elastics

They are used in mid-line adjustment. They extend from the upper intermaxillary hook to the intermaxillary hook on the opposite side (Figure 13). It is recommended to apply these with a force of 1½ - 2½ oz. [10].

Figure 13. Example of using diagonal elastics

Open-bite closure elastics

They are used to fix cases of open-bite. They may be applied in a vertical, triangular or box manner (Figure 14). Vertical types are used in a way that they extend from the bracket of each maxillary tooth towards the bracket of the mandibular teeth.

Vertical

Triangular

Box

Figure 14. Examples of using open-bite closure elastics

Box elastics

As it may be understood from the name, they are in the shape of a box and may be used in various cases. For example, they may be used to prevent the extrusion of teeth and increase intercuspation or fixing open-bite and reducing anterior open-bite.

They may be applied in a way that they show a continuity from the surroundings of the maxillary central teeth around the mandibular incisor teeth.

Lateral boxes may be applied around the maxillary lateral or premolar and mandibular premolar or molar teeth (Figure 15). It is recommended to apply these with a force of 6¼ oz. [10].

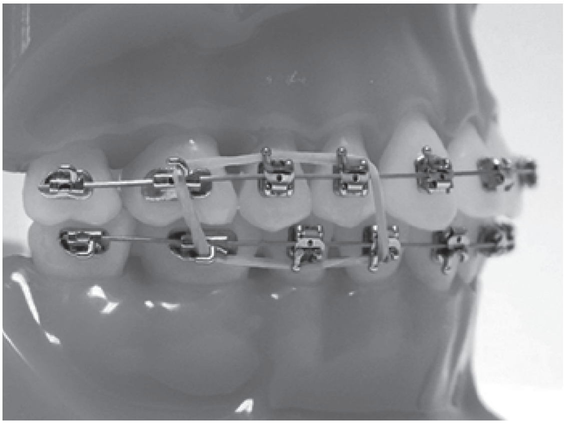

Figure 15. Example of using box elastics (Lateral box)

Triangle elastics

They improve class I occlusion, as well as adjusting overbite occlusion by closing the anterior opening by 0.5 mm – 1.5 mm. The maxillary or mandibular tooth is taken as the apical part of the triangle, while two teeth on the opposite chin are used as the base of the triangle (Figure 16). They resemble box elastics in terms of usage, but the difference between them is that triangle elastics are applied on three teeth. If one tooth is desired to be brought to occlusion, triangular usage is recommended. These are recommended for application with a force of 3½ oz. [10].

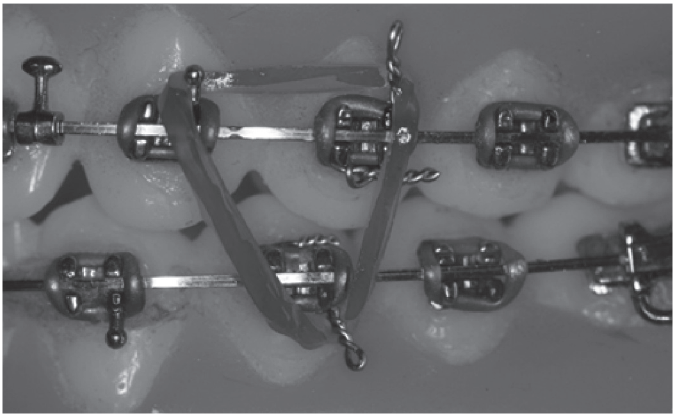

Figure 16. Example of using triangle elastics

4.2.6. Vertical elastics

It is appropriate to use these in cases where it would be difficult to close the occlusion. They are contraindicated in cases that are characterized by deep occlusion. It is recommended to apply these with a force of 3½ oz. [12].

Figure 17. Example of using vertical elastics

Lingual elastics

They are used as a support or a force balancer against buccal elastic forces. It is asserted that this will increase the effectiveness of force distribution [10].

Figure 18. Example of using lingual elastics

Control elastics

They are used in cases where the arch wire has a tendency to tip over molar teeth towards the distal for the purpose of directing the molar teeth towards the anterior part of the wire and achieving vertical anchorage [13].

4.2.7. Molar distalization elastics

To apply the elastic, the two hooks that are found in the buccal and the lingual of molar teeth are connected with an acrylic plate. The elastic is stretched from the mesial face of the molar, and this way, it distalizes the tooth on which it is applied [14].

4.2.8. Class I and class I tension elastics

They are used in the final adjustments of teeth. It is recommended to apply these with a force of 2 oz.

Therefore, the elastic is applied between all pairs of teeth in the occlusion, thus being applied to the central teeth on the opposite side of the mid-line.

4.3. Other elastics

4.3.1. Asymmetric elastics

They are usually used in cases where one side is class II and the other is class III. As it may be understood from the naming, their purpose is to solve dental asymmetry.

4.3.2. Finishing elastics

They are used to adjust posterior teeth at the final stage of treatment. In class II cases, the elastic continues along single-cusp maxillary teeth and ends in the maxillary molar tooth. It is recommended to apply these with a force of 2 oz. [10].

4.4. Based on forces

Table 1. Forces to be applied with elastics	
Light-pull	2½ oz.
Medium-pull	4½ oz.
Heavy-pull	6½ oz.

5. CONCLUSION

Orthodontic elastics have a broad place in current and modern orthodontic treatment. Especially in recent years, they have provided orthodontists with a broad field of usage as their negative aspects have been eliminated with advanced technology.

It should be kept in mind that patient cooperation is highly important in the use of elastics.

If the orthodontist who continues the treatment with elastics sees no results, in this case, they should question the patient in addition to the material.

When elastics to be applied carefully and with recommended forces are combined with patient cooperation and a good patient-physician relationship, they will definitely provide the orthodontist with an opportunity of a positive treatment process.

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Chapter 3

APICAL MICROLEAKAGE OF DIFFERENT ROOT CANAL SEALERS AFTER USING VARIOUS IRRIGATION SOLUTIONS AND Er:YAG LASER

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Begum Busra CEVVAL OZKOCAK[5]

INTRODUCTION

The main goals of endodontic treatment are to eliminate the microorganisms in the root canal system with chemomechanical preparation and to prevent re-infection by creating tight seals with biocompatible materials (Gutmann &Witherspoon, 2002, Mamootil &Messer, 2007,Siqueira et al., 1997). Since the root canal anatomy is a complex structure, mechanical preparation cannot entirelyrid theroot canals of bacteria and tissue residues that may befood sources for bacteria. *Ex vivo* and clinical studies have indicated that intact areas remain on root canal walls during mechanical preparation, and therefore, it is important to perform irrigation in addition to mechanical preparation (Mohammadi &Abbott, 2009, Peters et al., 2001)..

Besides irrigation solutions, various lasers have been used in root canal cleaning; in fact, they have been used to remove the smear layer from the dentin surface in both clinical and scientific research (Guneser,Arslan &Usumez, 2015, Gupta I et al., 2011, Gurbuz et al., 2008, Lagemann et al., 2014, Martins et al., 2014, Meire et al., 2012, Silva et al., 2012).

There is a strong relationship between the quality of endodontic treatment (i.e, with inadequate/adequate root canal obturation) and periapical lesions (Gillen et al., 2011, Nur et al., 2014). Inadequate root canal obturationsnegatively affect the

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success of endodontic treatment, thus causing a need for the treatment or surgery-to be repeated (Peters, 2004).. It has been reported that approximately 60% of the failures in endodontic treatment occur due to incompletely packed canal gaps. Therefore, the choice of chemomechanical preparation and irrigation methods is important in successful root canal treatment (De Deus et al., 2007, Gumru et al., 2011, Ingle J.I. et al., 1985, Michailesco &Boudeville, 2003).

Endodontic sealers are indispensable materials that seal the root canal (De Deus et al., 2007). Studies have revealed that gutta-percha results in significantly less leakage when it is used in additionwith sealers (Kontakiotis,Wu &Wesselink, 1997, Wu, Ozok& Wesselink, 2000). Despite all of the technological developments in the field of endodontics, no root canal obturationmaterial/technique provides impermeable sealing for root canal systems (Clark Holke et al., 2003). Therefore, new root canal obturation materials and techniques are being developed and presented for clinical use with each passing day; these claim to provide the expected sealing. AH Plus Jet, RealSeal, and SmartPaste Bio are newly developed some of root canal sealers. SmartPaste Bio is a bioceramics-based sealer that is mixed in asyringe and was introduced as ready-to-use.

Bacteria remaining in the canal should be eliminated with root canal obturation material, and the passage of bacteria and bacterial products into the root canal should be prevented with this sealing (El Sayed, Taleb &Balbahaith, 2013, Pawar,Pujar & Makandar, 2014). A review of the literature reveals that variations in the anatomy of the root canal, root canal filling methods, irrigation solutions, types of root canal sealers, preparation techniques, and the presence or absence of a smear layer affect microleakage (Lucena Martin et al., 2002, Roggendorf et al., 2007, Rosales Leal et al., 2011, Sagsen et al., 2006, Valois C.R.A. &. 2002, Vivacqua Gomes et al., 2002, Yildirim, Orucoglu &Cobankara, 2008). Therefore, the purpose of this study is to evaluate the interaction between root canal sealers, irrigation solutions, Er:YAG laser (Erbium: Yttrium Aluminum Garnet Laser) and dentin surface changes in terms of microleakage using a computerized fluid filtration technique.

MATERIALS AND METHODS

Ethical approval was obtained from the Clinical Research Ethics Committee of Gaziosmanpasa University Faculty of Medicine (project number: 16-KAEK-041). One hundred sixty newly extracted single root human mandibular premolars were used in this study. Radiographs were taken from the mesio-distal and bucco-lingual directions to confirm the presence of a single canal.Single canal teeth with similar root diameters were selected to be used in this study, while teeth with root caries or root fracture were excluded. Hard and soft tissue debris on teeth was removed with a scapel, and teeth were immersed in distilled water until further analysis. Crowns of the teeth were separated under the cementoenamel junction line to create equal root length. Root canals were prepared up to protaper F3 (Dentsply-Maillefer, Ballaigues, Switzerland) using rotary tools. Apex widths were controlled beyond 1 mm from the apex usinga #20 K-file (Dentsply-Maillefer, Ballaigues, Switzerland); those that were wider were excluded from the study.Five teeth were used as a negative control group, and 5 teeth were used as a positive control group. Then, the otherteeth were divided randomly into 3 main experimental groups (n= 50teeth each) according to their root canal sealer types. Each group was then divided into 5 subgroups (n=10) according to root canal disinfection methods. Group 1a, 2a, and 3a were irrigated with distilled water (ErdoğmuşKimya, Sivas, Turkey);group 1b, 2b, and 3b were irrigated with Ca(OH)2 solution (0,42g/100ml);group 1c, 2c, and 3c were irrigated with 5% NaOCl solution (Whitedentmed, ErhanKimya, Turkey);group 1d, 2d, and 3d were irrigated with 17% EDTA solution (Whitedentmed, ErhanKimya, Turkey) and group 1e, 2e, and 3e were irradiated by2940 nmwavelenghthEr:YAG laser (Kavo KEY laser 3+, KaVo, Biberach, Germany) and endodontic fiber tip (diameter ISO 30)with parametersof1W, 10Hz and 50mJ, for 1 minute.For each tooth, canal gaps were dried with paper point cones and obturatedwith guttapercha and root canal sealer. Then, teeth in group 1 were filled with AH Plus Jet (DentsplyDeTrey, Konstanz, Germany) and guttapercha (Protaper, DentsplyMaillefer, Ballaigues, Switzerland); teeth in group 2 were filled with SmartPaste Bio (DRFP Ltd., Stamford, UK) and guttapercha; and teeth in group 3 were filled with RealSeal root canal sealer (SybronEndo, Orange, CA, USA) and guttapercha. The cavity was sealed with temporary filling material (Cavit G, 3M ESPE, Seafeld, Germany) after the removal of the root canal obturationmaterial up to 2 mm below the canal aperture.

Groups were as follows:

- Group 1: AH Plus Jet (n=50)
- Group 1a (n=10): DistilledWater + AH Plus Jet + GuttaPercha
- Group 1b (n=10): Calcium Hydroxide + AH Plus Jet + GuttaPercha
- Group 1c (n=10): Sodium Hypochlorite + AH Plus Jet + GuttaPercha
- Group 1d (n=10): EDTA + AH Plus Jet + GuttaPercha
- Group 1e (n=10): Er:YAGlaser + AH Plus Jet + GuttaPercha
- Group 2: SmartPaste Bio (n=50)
- Group 2a (n=10): Distilled Water + SmartPaste Bio + GuttaPercha

- Group 2b (n=10): Calcium Hydroxide + SmartPaste Bio + GuttaPercha
- Group 2c (n=10): Sodium Hypochlorite + SmartPaste Bio + GuttaPercha
- Group 2d (n=10): EDTA+SmartPaste Bio + GuttaPercha
- Group 2e (n=10): Er:YAGlaser + SmartPaste Bio + GuttaPercha
- Group 3: RealSeal (n=50)
- Group 3a (n=10): Distilled Water + RealSeal + GuttaPercha
- Group 3b (n=10): Calcium Hydroxide + RealSeal + GuttaPercha
- Group 3c (n=10): Sodium Hypochlorite + RealSeal + GuttaPercha
- Group 3d (n=10): EDTA +RealSeal+GuttaPercha
- Group 3e (n=10): Er:YAGlaser + RealSeal + GuttaPercha
- Group 4: Negative Control (n=5)
- Group 5: Positive Control (n=5)

Samples were kept at 37 ºC and 100% humidityfor 30 days. Root surfaces were completely covered with two coats of nail polish beginning 2 mm above the apex until coronal. Teeth were placed in a serum tire in such a way that the canal aperture remained open, and they were fastened from the coronal region using cyanoacrylate adhesives. Samples were connected to a computerized fluid infiltration test device. Microleakage values were obtained by performing 8 measurements for each sample and taking the average under the pressure of 120 kPa (1.2 atm) using PC-compatible software (FluidFiltration'03, Konya, Turkey). The apical microleakage amount was evaluated in units of ml.cmH2O-1.min-1. Data analysis was performed with IBM SPSS for Windows 20 (SPSS Inc., Chicago, IL, USA). One-way ANOVA, post hoc Tukey HSD, and Tamhane T2 tests were used for the data analysis.

RESULTS

Results of the dataare presented in tables 1, 2, and 3, while comparisons between the groups are presented graphically in figure 1. There was no apical microleakage in the negative control group ($p<0.001$), while there was excessive apical microleakage in the positive control group (mean: 72×10^{-4} ml.cmH2O-1.min-1; $p<0.001$). There was a significant difference between the negative control group and all of the other groups, and there was also a significant difference between the positive control and all of the other groups ($p<0.001$). There were significant differences among the canal sealers and among the root canal disinfection methods. The bioceramics-containing sealer generally had lower mean values of apical microleakage, whileRealSeal had higher mean values of apical microleakage (Table 1). There was no significant difference between groups irrigated by distilled water and Ca(OH)2 with groups obturatedby AH Plus Jet and SmartPaste Bio. However, there was a statistical difference between groups in which NaOCl, EDTA, and Er:YAG laser were used with groups in which AH Plus Jet and SmartPaste Bio were used. There was a statistically significant difference between the SmartPaste Bio and RealSeal groups with regards to each disinfection method. When comparing AH Plus Jet and RealSeal sealers, there was a difference with distilled water, Ca(OH)2, and laser, but there was no difference withNaOCl and EDTA (Table 2).When comparing canal sealers in terms of surface application methods, there was a statistically significant difference between distilled water and all of the other groups, between Ca(OH)2 and EDTA, and between Ca(OH)2and laser groups for AH Plus Jet. With regards to SmartPaste Bio, there was a difference between distilled water and Ca(OH)2, between distilled water and NaOCl, and between distilled water and laser. With regards to RealSeal, there was a statistically significant difference between distilled water and NaOCl, between distilled water and EDTA, between Ca(OH)2 and laser, between NaOCL and laser, and between EDTA and laser ($p<0.001$)(Table 3).

Table 1: Mean and standard deviation (SD) values (in; µl.cmH_2O^{-1}min^{-1}) of apical microleakage for the experimental groups.

	Groups	**Mean**	**Std. Deviation**	**(n)**
AH PLUS JET	Distilled Water	7.51×10^{-4}	2.41×10^{-4}	10
	Calcium Hydroxide	11.66×10^{-4}	5.65×10^{-4}	10
	NaOCl	12.34×10^{-4}	4.04×10^{-4}	10
	EDTA	14.57×10^{-4}	6.86×10^{-4}	10
	Er:YAG laser	13.82×10^{-4}	3.62×10^{-4}	10
	Total	11.99×10^{-4}	5.36×10^{-4}	50
SMARTPASTE BIO	Distilled Water	7.74×10^{-4}	2.59×10^{-4}	10
	Calcium Hydroxide	10.13×10^{-4}	2.30×10^{-4}	10
	NaOCl	9.75×10^{-4}	3.54×10^{-4}	10
	EDTA	9.42×10^{-4}	5.19×10^{-4}	10
	Er:YAG laser	11.62×10^{-4}	5.10×10^{-4}	10
	Total	9.73×10^{-4}	4.11×10^{-4}	50
REALSEAL	Distilled Water	15.42×10^{-4}	4.58×10^{-4}	10
	Calcium Hydroxide	13.92×10^{-4}	4.32×10^{-4}	10
	NaOCl	12.90×10^{-4}	2.85×10^{-4}	10
	EDTA	13.60×10^{-4}	3.33×10^{-4}	10
	Er:YAG laser	16.05×10^{-4}	4.48×10^{-4}	10
	Total	14.38×10^{-4}	4.13×10^{-4}	50

Table 2. Multiple statistical comparisons between root canal sealers; * symbols indicate significant difference between groups (p <0.05).

	AH Plus Jet-SmartPaste Bio	AH Plus Jet-RealSeal	SmartPaste Bio-RealSeal
Distilled Water	p=0.918	*p<0.001	*p<0.001
Calcium Hydroxide	p=0.81	*p=0.015	*p<0.001
NaOCl	*p<0.001	p=0.867	*p<0.001
EDTA	*p<0.001	p=0.592	*p<0.001
Er:YAG laser	*p=0.006	*p=0.002	*p<0.001

Table 3. Multiple statistical comparisons between irrigation solutions and Er:YAG laser; * symbols indicate significant difference between groups (p<0.05).

	AH Plus Jet	SmartPaste Bio	RealSeal
Distilled Water–$Ca(OH)_2$	*p<0.001”	*p<0.001	p=0.297
Distilled Water - NaOCl	*p<0.001	*p=0.001	*p=0.001
Distilled Water - EDTA	*p<0.001	p=0.102	*p=0.047
Distilled Water - Er:YAG laser	*p<0.001	*p<0.001	p=0.992
$Ca(OH)_2$- NaOCl	p=0.991	p=0.996	p=0.76
$Ca(OH)_2$ - EDTA	*p=0.038	p=0.955	p=1.0
$Ca(OH)_2$- Er:YAG laser	*p=0.045	p=0.178	*p=0.026
NaOCl - EDTA	p=0.128	p=1.0	p=0.824
NaOCl - Er:YAG laser	p=0.150	p=0.79	*p<0.001
EDTA - Er:YAG laser	p=0.993	p=0.75	*p=0.001

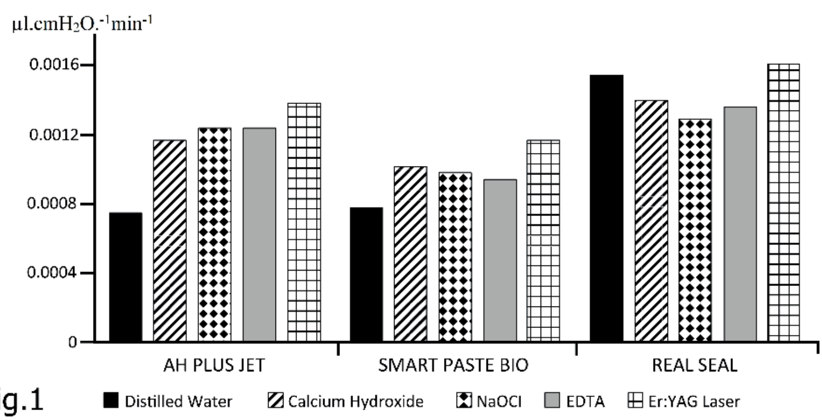

Fig.1

Figure 1. Graphic view of the results

DISCUSSION

Microorganisms in the root canal can remain active in the dentine tubules, even after an effective chemical and mechanical root canal preparation. A successful apical sealing is intended to prevent the entry of bacteria and endotoxins from the root apex into the canal (Lucena Martin et al., 2002, Pommel, Jacquot & Camps, 2001).Apical leakage is affected by obturationtechniques, the chemical and physical properties of the sealer, and the presence or absence of a smear layer (Lucena Martin et al., 2002, Valois C.R.A. &. 2002, Vivacqua Gomes et al., 2002). This study aimed to evaluate the impact of these interactions on apical microleakage.

Various experimental methods have been used to investigatemicroleakage in teeth that have undergone root canal treatment, but none has been accepted as the most effective method (Timpawat, Vongsavan & Messer, 2001).Researchers have used several methods, including dye penetration, the radioisotope method, the electrochemical method, the infiltration of bacteria and toxins, compressed air techniques, the glucose penetration model, and fluid filtration to determine microleakageof root canal sealers (Muliyar et al., 2014).

In their study, Wu et al. reported that the fluid filtration technique is more sensitive than the dye penetration method (Wu,De Gee & Wesselink, 1994).

Timpawat et al. reported that the bacterial microleakage test successfully reflects clinical and biological conditions, and suggested that this method be used (Timpawat, Amornchat & Trisuwan, 2001). That sterile and careful study is of great importance in bacterial microleakage experiments. However, this method has some disadvantages, such as the need for microbiologists, the risk of microorganism transmission from the external environment, that non-sterile equipment cannot be used, that the hands of the physicians must be kept sterile during sample preparation or sectioning, and that there may be incorrect results due to antibacterial products or the antibacterial properties of the tested material (Maltezos et al., 2006, Moradi, Lomee & Gharechahi, 2015, Schafer & Olthoff, 2002).

The fluid filtration method used in our current study has been shown to have important advantages in endodontic leakage studies. This method yields more reliable quantitative volumetric data for microleakage measurements, and these measurements take less time than do other methods. In addition, this method does not harm the samples, which enables repeated measurements on the same sample at specific time intervals.

Condon and Ferracane reported that shrinkage stresses emerge more often during polymerization in methacrylate-based root canal sealers, which are made of low-viscosity cements with less filling portions, than they do in resin composites with more filling portions (Condon & Ferracane, 2000).

De-Deus et al. filled root canals with a lateral condensation obturationtechnique using AH Plus, Pulp Canal Sealer EWT, Roekoseal, and GuttaFlow sealers and determined their sealing properties with the polymicrobial leakage model. In 3-, 6-, and 9-week periods, AH Plus and Pulp Canal Sealer EWT showed more leakage, but there was no statistically significant difference between Roekoseal and GuttaFlow. The authors associated the success of the silicon-based sealers with their expansion properties (De Deus et al., 2007).

Monticelli et al. compared Activ GP and GuttaFlow systems, 2 different single conepacking techniques, and the technique of condensation with continuous heat with bacteria leakage test using AH Plus/gutta percha. Their study continued for 100 days. At the end of 2 months, leakage was observed in 91.6% of the samples in the Active GP group. At the end of 100 days, the best sealing value was obtained in the AH Plus/gutta percha group. The study's authorssurmised that the very early leakage of Active GP was due to it being a glass ionomer based system, which showed shrinkage during setting, and had a gap between the sealer and the dentin wall (Monticelli et al., 2007).

In present study, the RealSeal groupshad higher microleakage values, which is similar with the results mentioned above. This may be explained by the fact that the RealSeal root canal sealer is a dual cure sealer and is known to shrink during polymerization.

Biggs et al. found that canal fillings with Resilon/Epiphany is not superior to other methods, including gutta-percha/Roth and gutta-percha/AH Plus, using fluid filtration test (Biggs et al., 2006).

Paque and Sirtes applied the fluid filtration test to samples just after obturation and at the 16th monthand compared Resilon/Epiphany and gutta-percha/AH plus groups in their long-term leakage study. There was no difference between groups in terms of leakage after obturation; however, there was more leakage in Resilon /Epiphany group at the 16th month. The authors indicated that this increased leakage was due to the degradation of polymers caused by physical and chemical processes over time (Paque &Sirtes, 2007).

In our current study, the highest microleakage values were observed in the RealSeal group in the canals obturated with a single cone method. There was no significant difference when comparing AH Plus- RealSeal root canal sealers with NaOCl and EDTA; however, there were statistical differences between groups while using distilled water, Ca(OH)2, and Er:YAG laser. Further, AH Plus had lower microleakage values. Smartpaste Bio had significantly lower apical microleakage values than did the RealSeal group regardless of the irrigation solution type. As researchers have reported, the characteristics of root canal sealers have determined these results to a large extent. Smartpaste Bio is a root canal filling sealer that has a hydrophilic character and needs water for polymerization (Moura Netto et al., 2012). For this reason, we believe that it expanded during polymerization. However, the RealSeal group had shrinkage during polymerization, and the resulting gap increased the microleakage.

Adanir et al. compared microleakagesoccurring in root canals obturatedby three different resin based sealers (AH26, Diaket, EndoREZ) and zinc oxide eugenol based U/P Root Canal Sealer according to a lateral condensation gutta-percha method using the fluid filtration method.In that study, there was no significant difference among resin-based sealers, while on the other hand;the zinc oxide eugenol-based sealer had significantly more leakage. The authors reported that AH26, an epoxy resin-based sealer, had good adhesive and sealing properties (Adanir, Cobankara & Belli, 2006).

Shemesh et al. compared root canals packed with AH26 and the gutta-percha lateral condensation method in the presence or absence of a smear layer androot canals filled with the Epiphany system (according to the lateral condensation method) using both glucose penetration and fluid filtration methods. The authors reported that removing the smear layer did not increase the sealing capability, and that the Resilon/Epiphany system had higher glucose penetration for 56 days (Shemesh,Wu & Wesselink, 2006).

Saleh et al. reported that bacterial penetration is slower in all groups in the presence of the smear layer (Saleh et al., 2008).

The results of the current study are in accordance with the results of published studies, in that more apical leakage was observed in caseswhere the smear layer was removed (EDTA, laser use). In cases with AH Plus root canal sealer, microleakage values decreased with use of EDTA, while they increased with the Er: YAG laser in cases with RealSeal root canal sealer. Apical microleakage values for all three root canal sealers became higher, especially while using the Er: YAG laser. In our opinion, this occurred because the sealer did not show good fluidity and coverage on irregular micro-retentive areas that wereformed in the dentin surface.

Saleh et al. expressed that although Apexit root canal filling sealer has avery low bond strength to dentin, it leads to less bacteria leakage than does the AH Plus sealer, which has high bond strength. Thus, they suggested that there is no need for high bond strength to prevent the entrance of bacteria into the root canal (Saleh et al., 2008).

Tagger et al. indicated that the strong bond of root canal sealer to dentin does shows that not all of the root canal is covered by the sealer, and that there may be some micro gaps despite the strong bond (Tagger et al., 2002).

Perdigao et al. proposed that reducing the shrinking stress of root canal sealers and preserving the integrity of the canal obturationplay a more important role in preventing microleakage than does adhesion (Perdigao,Lopes &Gomes, 2007).

In addition, the results of these previous studies and the current study are consistent. In a previous study, researchers demonstrated that root canal sealers could be not penetrated in every situation, even if the dentin tubules are open, and we presented with the support of SEM that adhesion values are not high in all conditions, even in case of penetration. Bioceramic based root canal sealer, which has a lower bond strength had lower microleakage values in this study. On the other hand, higher apical microleakage was found in sealers with high bond strength (Ozkocak & Sonat, 2015).

CONCLUSION

The physical and chemical properties of root canal sealers, irrigation solutions, root canal obturationmethods, disinfection methods, dentin surface changes, and sealer- solution interactions are the factors that affect the quality of root canal filling and the prognosis of endodontic treatment. Clinicians should choose materials after considering the characteristics of the root canal filling material or irrigation solutions or lasers and the impacts of them on the dental tissue for the long-term success of root canal treatment. Results of this study suggest that, although no sealer completely sealed the teeth (i.e.,leakproof), the bioceramics based root canal sealer had lower microleakage values. Conditions in which the smear layer was removed generally caused an increase in microleakage values.

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Chapter 4

MULTIMODALITY IMAGING OF AN ANTERIOR STATIC BONE CAVITY WITH THREE YEAR FOLLOW-UP: A CASE REPORT

Nazan KOÇAK[1]

INTRODUCTION

Static Bone Cavities (SBCs), also referred to as lingual mandibular bone defects, idiopathic bone cavities, static bone defects, or ectopic salivary glands, are generally found in the posterior portion of the mandible in men 50 to 70 years old (Stafne, 1942); an SBC in the literature most often refers to this specific type. SBCs are asymptomatic bone lesions diagnosed during routine radiographic examinations that were first described by Edward Stafne, who reported 35 discrete cases (Segev, Puterman & Bodner, 2006). Seventy-seven SBCs have been reported since according to the PubMed literature database, with around fourteen of them Anterior Static Bone Cavities (ASBCs). These types of cavities in the anterior region are therefore somewhat unusual.

Four different types of SBCs have since been identified. Richard & Ziskind first reported ASBCs in 1957. Philipsen & et al. described them as radiolucent, lingual, open-ovoid concavities in the canine-premolar mandibular region, and reported that they were seven times less frequent than those found in the posterior region (Philipsen & et al., 2002). Philipsen and his colleagues also discovered posterior SBCs located between the mandibular angle and the first permanent molar, below the inferior dental canal, alongside the anterior type located between the incisor and the premolar areas, and above the insertion of the mylohyoid muscle. Philipsen's team went on to describe buccal and lingual SBCs at the ascending ramus of the mandible while noting that these were exceedingly rare (Philipsen & et al., 2002). These other types may also be visualized incidentally on routine panoramic radiographic evaluation.

ASBCs may be confused with other pathologies owing to their location and low rate of occurrence. Differential diagnosis can be exhaustive, but correct interpretation and diagnosis of these lesions are crucial to prevent unnecessary excision. A diagnosis of SBC is therefore usually confirmed with a follow-up

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panoramic view (Etöz & et al., 2012). Further evaluation can be undertaken with Cone-Beam Computed Tomography (CBCT), Computed Tomography (CT), or Magnetic Resonance Imaging (MRI), as well. The purpose of this article is to evaluate a new case of ASBC, including its radiographic features and differential diagnosis.

CASE REPORT

A 61-year-old male patient was referred to our clinic for endodontic and periodontal complaints. As the patient had previously received surgery to address colon cancer, we decided to evaluate him carefully. No abnormal findings presented during the oral examination and a panoramic radiographic evaluation was recommended. The panoramic radiographs revealed a sclerotic, well-defined, radiolucent area at the right canine-premolar region of the mandible below the tooth roots (Figure 1). This oval-shaped, radiolucent lesion was unilocular with a diameter of almost 2 cm, with emphasized radiopaque margins around the lesion (Figure 1A).

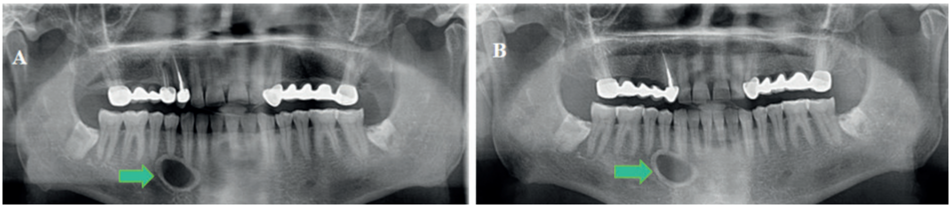

Figure 1A. Panoramic image of the first examination of the patient, 1B: After follow-up panoramic view one year later

The lesion was otherwise asymptomatic, despite being in close proximity to the roots of the teeth. The teeth responded positively to vitality tests. CBCT was performed to reveal the lesion's exact margins (KODAK 9000 3D, Kodak Dental Systems, Carestream, Rochester, NY, USA).

The CBCT image showed that the lesion reached the medial side of the buccal cortex, extending both medially and distally. Hyperdense sclerotic margins were also noticeable. The lesion had eroded the lingual cortical bone and caused a small buccal expansion, leaving only a thin layer of bone. The lesion was located under the right mandibular canine and above the mental foramen (Figure 2).

Its longest axis was placed horizontally in the canine and premolar region to the right of the hemimandible, and the upper wall of the lesion suggested a close relationship with the apices of the teeth. The lower wall of the lesion was located at a 2 mm distance from the incisive mandibular nerve. The lingual wall of the basal bone also displayed involvement of the lesion, and precise dimensions of the defect were 12.6 mm by 11.6 mm by 11.2 mm (mesiodistal length, inferosuperior height, and buccolingual depth, respectively). The patient reported no pain or paraesthesia and was informed that further evaluation was needed to distinguish the lesion from other pathologies. The soft tissue algorithms of CT and CBCT were insufficient to show the level of contact between the lesion and adjacent soft tissue, necessitating an MRI scan. The patient had had CT (Figure 3) and MRI (Figure 4) images taken from another hospital three years prior.

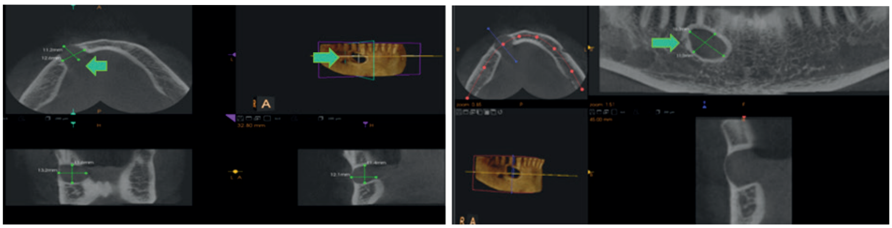

Figure 2. CBCT image of the first examination

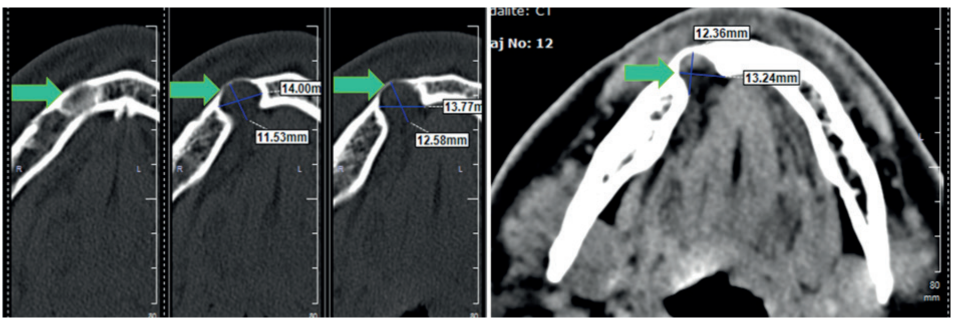

Figure 3. CT image taken at an external centre, two years before the first examination

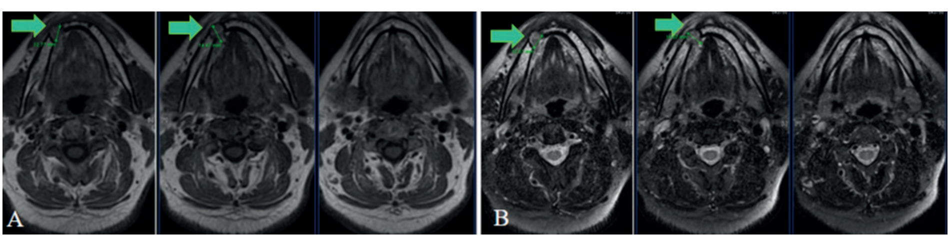

Figure 4. MRI image taken at an external centre, two years before the first examination

Following an MRI, the lesion was definitively diagnosed as an anterior presentation of an SBC. An ASBC is considered an anatomical rather than a pathological condition and does not require surgical treatment. The patient was prescribed yearly monitoring with panoramic radiographs. The shape and the size of the lesion were unchanged one year after initial diagnosis (Figure 1B), the overlying mucosa of the cavity was normal, and there was no sign of infection or fistula. At that time, the diagnosis of ASBC was finalized, and follow-up for the patient was increased to three years, again with CT and MRI scans.

Unenhanced MRI was taken in the external centre. On unenhanced axial, fat-supressed $T1$ and $T2$ sequences, the cavity was observed to extend into canine curvature of the mandibula from the adjacent soft tissue (Figures 4A, 4B). The cavity displayed the same signal intensity in both sequences, while the unenhanced $T1$ sequences perfectly depicted the lesion's margins and demonstrated continuity between the sublingual gland and the defect (Figure 4B).

In addition to subsequent clinical examination, the patient was imaged with panoramic radiography, CBCT, CT, and MRI at specific intervals, and the size and contour of the lesion remained unchanged. When unaccompanied by pathology, conservative management is recommended for ASBC. In this case, a radiological follow-up was recommended for three years hence.

DISCUSSION

Generally, SBCs are developmental lesions, and that tend to contain ectopic submandibular glands (Apruzzese & Longoni, 1999). However, other structures, such as lymphoid tissue, connective tissue, fat, muscle, or vascular tissues, have also been associated with SBCs (Slasky & Bar-Ziv, 1996). Although ASBC and SBC aetiologies remain undefined, the most widely accepted aetiopathogenesis is that the cavities develop as a result of localized pressure at the lingual surface of the mandible from the adjacent salivary gland (Dereci & Duran, 2012). While the submandibular gland is implicated in the SBC, the sublingual gland is thought to be the cause of an ASBC. The parotid gland may be associated with the buccal or lingual variants of these cavities at the ascending ramus of the mandible (Philipsen & et al., 2002), (Barker, 1988). Local influence of arterial pulses can cause bone resorption, as patients with cardiovascular disease are more likely to present with these cavities (Shimizu & et al., 2006). In this case report, aetiopathogenesis of the cavity was determined to be localized pressure from the sublingual gland. The patient did not present with cardiovascular disease. In this case and others with similar characteristics, such structures do not require surgical interventions. The ectopic sublingual gland also did not need to be treated in this patient.

In most panoramic radiographs, the diagnosis of SBC is plain in relation to other lesions, with a typical, cyst-shaped, oval radiolucency alongside sclerotic bone thickening and continuity with the base of the mandible, and is located around the gonial angle under the mandibular canal (Philipsen & et al., 2002). Certain cavities, similar to the one in this case report, however, may not be typical with regards to traditional panoramic images.

These cavities are located somewhat higher and are not found in relation to the mandibular base, and may appear as cysts. In fact, the cavity (Figure 1) was diagnosed as a true cystic lesion following panoramic radiography. Corroboration using CT/CBCT and/or MRI is recommended to exclude other possibilities, as Stafne's bone cavity only reveals an obvious lingual defect in the mandibular bone through these advanced diagnostic modalities (Saglam & et al., 2013).

Sekerci & Sisman, 2014 reported that the incidences of SBCs and ASBCs ranged from 0.081% to 0.48% and 0.003% to 0.48%, respectively. ASBCs are more difficult to diagnose than SBCs (Taysi & et al., 2014). When ASBC cases have been reported, surgical exploration or biopsy was frequently performed before diagnosis (Turkoglu & Orhan, 2010), likely due to the ASBC's location. An ASBC may resemble other radiolucencies such as benign or malignant mandible lesions, odontogenic cystic lesions, non-ossifying fibromas, neurofibromas, fibrous dysplasia, vascular malformations, multiple myelomas, eosinophilic granulomas, focal osteoporotic bone marrow defects, ameloblastomas, basal cell nevus syndrome, giant cell tumours, or metastasis from a primary malignant tumour (Taysi & et al., 2014), (Turkoglu & Orhan, 2010). In this particular case, jaw bone cysts and benign and malignant tumours were excluded from the differential diagnosis because the cavity displayed continuity with the adjacent salivary gland on the axial section of the MRI. When the diagnosis is suspect or clinical symptoms are present, surgical excision or biopsy should be performed to rule out other pathologies (Dereci & Duran, 2012). However, no signs of inflammatory or tumoral changes were found in our patient, so no surgical interventions were necessary, and the patient was instead recommended for regular radiological follow-ups.

Advanced diagnostic imaging such as CBCT, CT, and MRI are non-invasive, easy to perform, and of exceptional clinical utility in diagnosis and follow-up; in fact, such techniques may be necessary to reach a definitive diagnosis. Axial images can easily define the borders of the mandible and can demonstrate the size and extent of the cavity. Smith & et al., 2017 diagnosed an ASBC using CBCT, reported as a useful diagnostic tool for maxillofacial hard tissue due to its lower radiation exposure and higher speed. CBCT has gained increasing popularity in dentistry due to its lower radiation, limited area of exposure, higher resolution, and availability compared to medical CT (Okano & et al., 2009). CBCT simplifies both diagnosis and follow-up, particularly through high resolution imaging that enables the visualization of specific radiographic features in fine detail.

In our case report, CBCT was used to yield high resolution images with less radiation exposure to the patient. Segev, Puterman & Bodner, 2006 recommended that the cavities identified on CT images be supported by MRI findings to define the content and extent therein, which was found to be the case in this report. An MRI can provide much better resolution of soft tissue, and also enables multiple imaging sections and different echo sequences while not exposing the patient to ionizing radiation; this was a critical factor in this case study. The MRI revealed that the mandibular cavity contained soft tissue continuous and isointense with the sublingual gland on both *T*1 and *T*2 sequences. The lesion was definitively diagnosed as an ASBC as a result of the MRI.

Another diagnostic technique is sialography, which can determine whether glandular tissue exists in the cavity. A major drawback, however, is that sialography is both invasive and irritating for patients. Sialographic evaluation of ASBCs is also relatively challenging due to the presence of multiple ducts in the sublingual gland and was thus not used in this instance (Araiche & Brode, 1959).

CONCLUSION

ASBCs are incidental findings, particularly on panoramic radiography, and are generally considered anatomical rather than pathological abnormalities. These cavities do not have any alarming impacts on the surrounding structure, and surgical intervention is not necessary except when symptomatic or other accompanied by other pathologies. Conservative management and regular, long-term, radiological follow-ups are recommended instead. ASBCs should be analysed using advanced diagnostic imaging such as CBCT, CT, and/or MRI to exclude similar lesions.

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Chapter 5

RADIODIAGNOSTIC APPROACH TO TRAUMATOLOGY IN PEDIATRIC DENTISTRY PART 1

Hilal ÖZBEY[1]
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Injuries to the teeth and facial skeleton are common. The type and severity of injuries can vary considerably, from minor damage to the teeth to sorely comminuted fractures of the skull.

Although the type of injury may be evident clinically, radiographic inspection of all traumatized teeth is needed initially, to assess fully the degree of underlying damage (Whaites & Drage, 2013). The ideal radiologic examination may be difficult to perform after trauma because of the patient discomfort. Although the prescription of the appropriate radiographs should be ordered only after a careful clinical examination, in some cases this is not always possible (White & Pharoah, 2014). Whatever the suspected injury, radiography is an essential requirement both in the initial assessment and in the follow-up examinations.

The diagnostic information provided by the radiographs may include; the type of injury to the teeth (Whaites & Drage, 2013), presence of root fractures, fracture regions, extent of displacement of the tooth fragment, degree of extrusion or intrusion, stage of root development, size of the pulp chamber and root canal, condition of the apical tissues, presence, site and displacement of alveolar bone fractures, presence of jaw fractures, condition of adjacent or underlying teeth, evidence of healing, post-trauma complications including resorption, infection, cessation of tooth development, tooth fragments and foreign bodies lodged in soft tissues, location of the tooth if swallowed or inhaled (Whaites & Drage, 2013; Ghom & Ghom, 2016; Ozdede & al., 2016).

There is great value in using panoramic radiographs in young children. In the very upset or difficult child, it may be the only way that some clinical information can be gained in the acute phase of management (Cameron & Widmer, 2008). Although a panoramic image may be useful for localizing injuries to the teeth and supporting structures, it may not have the image resolution to reveal injuries of anterior region teeth. Dentoalveolar trauma always requires intraoral radiographs

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to obtain adequate anatomic detail (White & Pharoah, 2014). A minimum of two periapical images from different angulations should be taken to identify tooth fractures. Additionally, occlusal radiographs are also important. Radiography of the teeth of the opposing arch may be useful. More recently, small field of view cone-beam computerized tomography (CBCT) has been used to identify tooth and bone fractures, luxation injuries. The CBCT scan provides three dimensional (3D) analysis of the maxillofacial region with excellent accuracy and high spatial resolution (İçöz & Akgünlü, 2016). Although the high resolution of CBCT systems may be beneficial to image such fractures, their availability is limited, and usage is not currently considered routine (White & Pharoah, 2014; Cameron & Widmer, 2008; Ozdede & al., 2016). If there are lacerations in the lips or cheek, a soft tissue radiograph of the region may be obtained by placing an intraoral film or receptor in the mouth adjacent to the traumatized soft tissue and then exposing it. If the laceration is in the tongue, a standard mandibular occlusal radiograph may be taken, or the tongue can be protruded and then imaged (White & Pharoah, 2014). The floor of the mouth can be best visualised by an occlusal film with the beam directed from submental approach (Ghom & Ghom, 2016). If a tooth or a large fragment of a tooth is missing, a chest or abdominal radiograph may be considered to locate the tooth (White & Pharoah, 2014).

The radiographs required for the examination of a trauma patient should be determined by the dentist after clinical examination and should be specific to the case (Kim & Mupparapu, 2009). The type, the number and the dose should be peculiar to the case. The risk of exposure to radiation and the information to be obtained from the radiographic examination should be compared. 'The minimum possible dose of radiation' criteria should be taken into consideration when making these decisions (Kullman & Al Sane, 2012). Today, with the development of digital radiography methods, it is possible to obtain quality images at lower doses. Due to prevalance of trauma in children and the susceptibility of children to radiation-related complications, guidelines for the use of appropriate radiographies in childhood have been prepared (American Academy of Pediatrics, 1998). In these guides; the sutures in the head bones that are not closed and the presence of adipose tissue on the bones have been reported as factors that reduce the diagnostic accuracy in children (Zimmermann, Troulis & Kaban, 2006). It has been reported that three-dimensional imaging gives more accurate results in studies comparing conventional films and CBCT, in follow-up appraisal of post-traumatic periapical pathologies (Stavropoulos & Wenzel, 2007; Lofthag-Hansen & al., 2007). However, it should be assessed by the dentist whether or not this evaluation is necessary considering the radiation dose given in these cases (Suomalainen & al., 2007).

The classification used in this chapter is based on a system adopted by the World Health Organization in its application of the International classification of Disease to Dentistry and Stomatology. This classification can be applied to both the primary and the permanent dentition (World Health Organization, 1995; Andreasen, Andreasen & Andersson, 2007).

1. Injuries to the Hard Dental Tissues and the Pulp

- Enamel Infraction
- Enamel Fracture (Uncomplicated Crown Fracture)
- Enamel Dentin fracture (Uncomplicated Crown Fracture)
- Complicated Crown Fracture (Enamel Dentin Pulp Fracture)
- Uncomplicated Crown Root Fracture (Crown Root Fracture without Pulp Exposure)
- Complicated Crown Root Fracture (Crown Root Fracture with Pulp Exposure)
- Root Fracture

2. Injuries to the Periodontal Tissues

- Concussion
- Subluxation
- Extrusive Luxation
- Lateral Luxation
- Intrusive Luxation
- Avulsion

3. Injuries to Supporting Bone

- Comminution of the Maxillary Alveolar Socket
  Comminution of the Mandibular Alveolar Socket
- Fracture of the Maxillary Alveolar Socket
  Fracture of the Mandibular Alveolar Socket
- Fracture of the Maxillary Alveolar Process
  Fracture of the Mandibular Alveolar Process
- Fracture of the Maxilla
  Fracture of the Mandible

4. Injuries to Gingiva or Oral Mucosa

- Laceration of Gingiva or Oral Mucosa
- Contusion of Gingiva or Oral Mucosa
- Abrasion of Gingiva or Oral Mucosa

1. INJURIES TO THE HARD DENTAL TISSUES AND THE PULP

Enamel Infraction

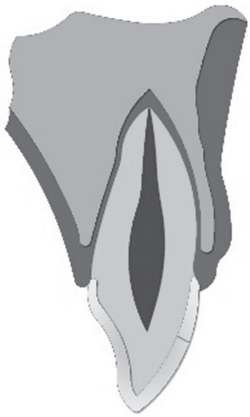

Figure 1. Diagram illustrating the enamel infraction of the permanent tooth.

A periapical image is recommended for infraction (Figure 1) type dental injuries. Normal radiographic findings are observed in periapical radiographs. If there is any other symptoms or signs, additional radiographs as occlusal and panoramic radiographs can be prescribed (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008).

Enamel Fracture (Uncomplicated Crown Fracture)

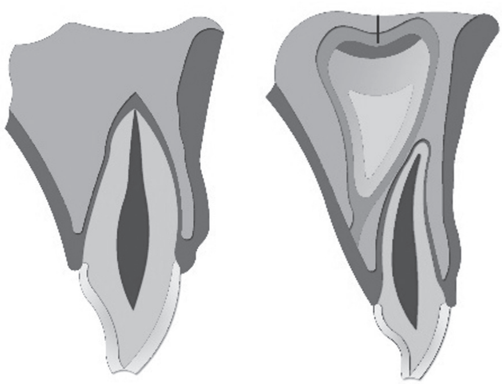

Figure 2. Diagram illustrating the enamel fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for enamel fractures (Figure 2), in order to exclude the possible presence of a root fracture or luxation type injury. Enamel loss is visibly observed in radiographic images (Figure 3a-b). Radiographs give information regarding the location and extent of the fracture and the relationship of the fracture plane to the pulp. Additionally, the stage of root development of the affected tooth can be assessed. Initial radiographs provide a comparison for follow-up examinations of affected tooth. If the tooth fragment is missing, radiograph of lip and cheek can be prescribed to search for the tooth fragment or foreign materials. (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008)

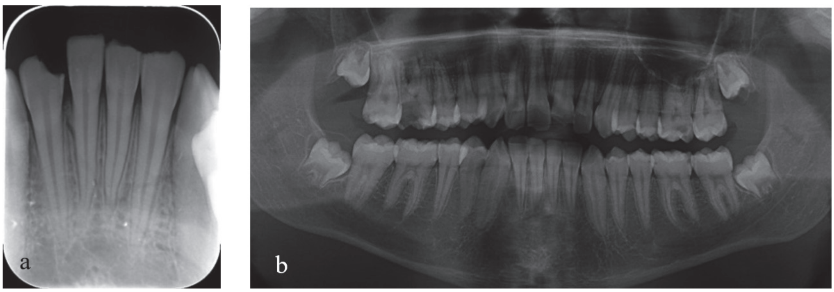

Figure 3a. Enamel fracture of teeth 31 and 32 and enamel-dentin fracture of tooth 42 of a 13 years old boy. **3b.** Enamel fracture of tooth 11 and enamel-dentin fracture of tooth 21 of a 15 years old boy.

Enamel Dentin Fracture (Uncomplicated Crown Fracture)

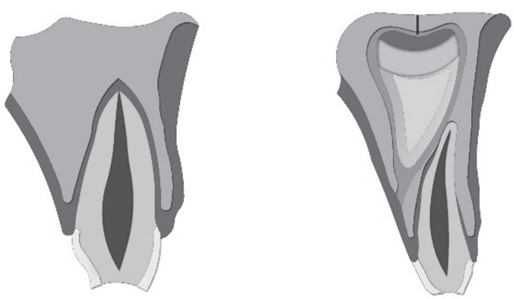

Figure 4. Diagram illustrating the enamel-dentin fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for enamel-dentin fractures (Figure 4), in order to exclude the possible presence of a root fracture or luxation type injury. Enamel-dentin loss is visibly observed in radiographic images (Figure 5a-b, 6) Radiographs give information regarding the location and extent of the fracture and the relationship of the fracture plane to the pulp. Additionally, the stage of root development of the affected tooth can be assessed. Initial radiographs provide a comparison for follow-up examinations of affected tooth. If the tooth fragment is missing, radiograph of lip and cheek can be prescribed to search for the tooth fragment or foreign materials (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008).

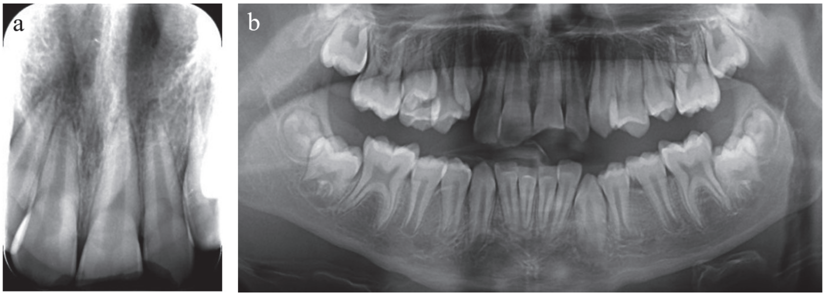

Figure 5a-b. Enamel dentin fracture of teeth 11, 21 and 22 of a 11 years old boy.

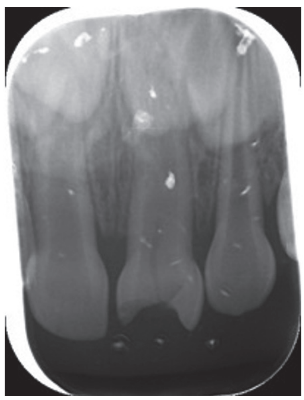

Figure 6. Enamel-dentin fracture of tooth 61 of a 3 years old boy.

Complicated Crown Fracture (Enamel Dentin Pulp Fracture) (Crown Fracture with Pulp Exposure)

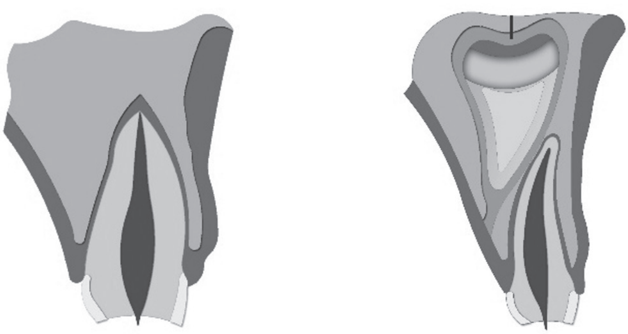

Figure 7. Diagram illustrating the complicated crown fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for enamel-dentin-pulp fractures (Figure 7), in order to exclude the possible presence of a root fracture or luxation type injury. Enamel-dentin loss is visibly observed in radiographic images (Figure 8a-b). Radiographs give information regarding the location and extent of the fracture and the relationship of the fracture plane to the pulp. Additionally, the stage of root development of the affected tooth can be assessed. Initial radiograph provides a comparison for follow-up examinations of affected tooth. If the tooth fragment is missing, radiograph of lip and cheek can be prescribed to search for the tooth fragment or foreign materials (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008).

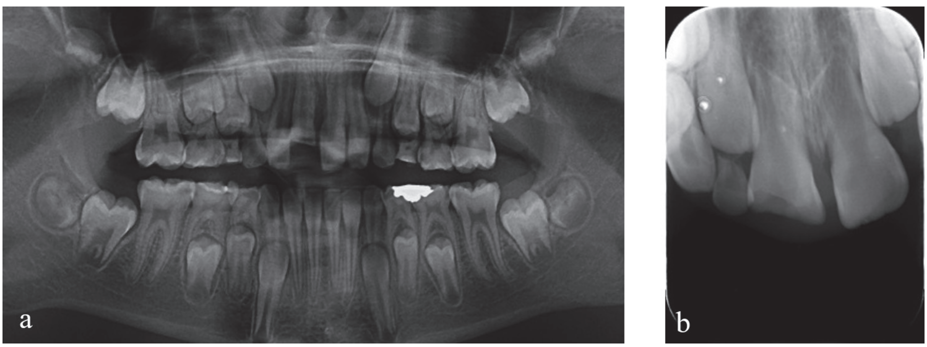

Figure 8. a. Enamel-dentin pulp fracture of tooth 11 of a 9 years old girl. **b.** Enamel-dentin pulp fracture of tooth 11 of a 8 years old boy.

Uncomplicated Crown Root Fracture (Crown Root Fracture without Pulp Exposure)

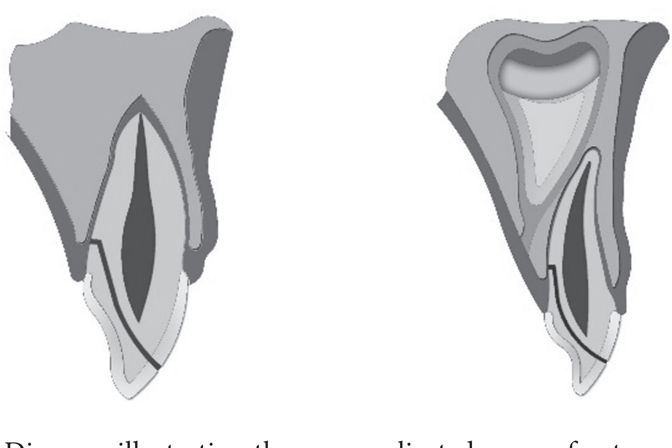

Figure 9. Diagram illustrating the uncomplicated crown fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for crown root fractures without pulp (Figure 9). Apical extension of fracture is usually not observed in radiographic images. Radiographs give information about the fracture lines in the root. Additionally, the stage of root development of the affected tooth can be assessed. Initial radiograph provides a comparison for follow-up examinations of affected tooth. If the tooth fragment is missing, radiograph of lip and cheek can be prescribed to search for the tooth fragment or foreign materials (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008)

Complicated Crown Root Fracture (Crown Root Fracture with Pulp Exposure)

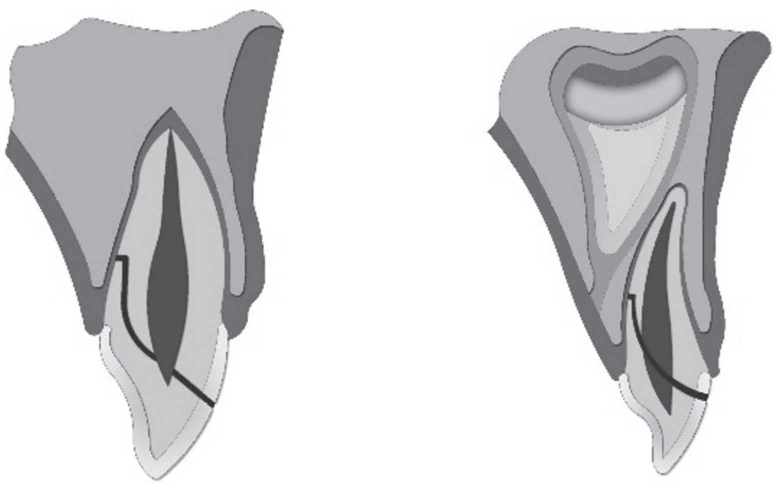

Figure 10. Diagram illustrating the complicated crown root fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for enamel fractures crown root fractures with pulp exposure (Figure 10). Radiographs give information about the fracture lines in the root. However, apical extension of fracture is usually not observed in radiographic images. Additionally, the stage of root development of the affected tooth can be assessed. Initial radiograph provides a comparison for follow-up examinations of affected tooth. If the tooth fragment is missing, radiograph of lip and cheek can be prescribed to search for the tooth fragment or foreign materials (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008).

Root Fracture

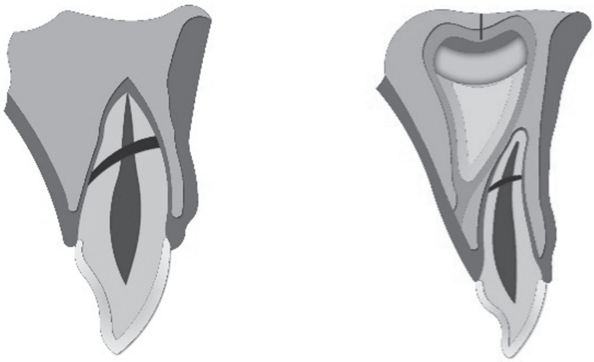

Figure 12. Diagram illustrating the root fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs, images taken from different angles and small volume CBCT images are recommended for root fractures (Figure 12). The fractures may occur in a horizontal, vertical or oblique manner. A radiolucent line between the fragments and an alteration in the outline shape of the root and discontinuity of the periodontal ligament shadow are observed in radiographic inspection (Figure 13a-b). Additionally, the stage of root development of the affected tooth can be assessed. Small volume CBCT system are of great value in the identification of root fractures and also enable the user to visualize the fracture in multiple planes of view. Initial radiographs provide a comparison for follow-up examinations of affected tooth (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014).

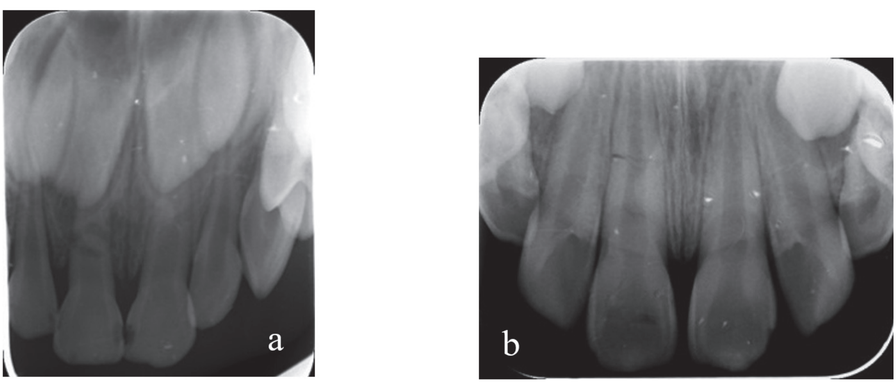

Figure 13. a. Root fracture of tooth 51 of a 3 years old boy. **b.** Root fracture of tooth 11 of a 9 years old girl.

The radiographic appearances can be influenced by the position and severity of the fracture, the degree of separation of the fragments and the position of the film and x-ray beam in relation to the fracture plane (Figure 14). Therefore, a minimum of two exposures (Figure 15,16), from two different angles, is essential if small volume CBCT is not available (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; Whaites & Drage, 2013).

The width of the gap between the fracture fragments tends to increase with time, probably because of resorption of the fractured surfaces. Over time, obliteration of the pulp chamber and root canal may be visualized.

Alveolar fractures, small neurovascular canals, soft tissue structures (lip, ala of the nose, nasolabial fold) may imitate like a root fracture. It is important to make diffrential diagnosis in these cases (White & Pharoah, 2014).

Fractures that are in the horizontal plane may occur at any level of the root and involve one or all of the roots of multirooted teeth. However, most of the fractures occur in the servical third of the root. On the other hand, most of the oblique fractures occur in the apical third of the root. Occlusal radiographs, periapical radiographs exposed from different angles and small volume CBCT images are recommended for identification of horizontal and oblique fractures. Horizontal fractures can usually be detected in the regular periapical 90° angle film with the central beam through the tooth. Thereby, a single sharply defined radiolucent line confined to the anatomic limits of the root may be observed. However, if the x-ray beam meets the fracture plane in a more oblique manner, a more poorly defined single line or as two lines that converge at the mesial and distal surfaces of the root may be observed. The appearance of comminuted root fractures and nondisplaced root fractures are usually difficult to detect, and several images from different angles may be needed. In some cases when the fracture line is not visible, a localized widening of the periodontal ligament space adjacent to the fracture plane may be used as a sign of root fracture (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014).

Vertical root fractures are not common but occur most likely in teeth that have been endodontically treated and include root canal filling materials or posts in it. These high-density materials can create image artifacts that can reduce image quality and make the fracture diagnosis difficult. Although x-ray orientation is not a limitation for CBCT imaging, lack of separation of fracture fragments and image artifacts from dental materials in the root, make diagnosis of a radiologic root fracture a challenge. In some cases where the fracture line is not visible on any imaging modality, focal widening of the periodontal ligament space along the tooth root surface may be used as a sign of root fracture (White & Pharoah, 2014).

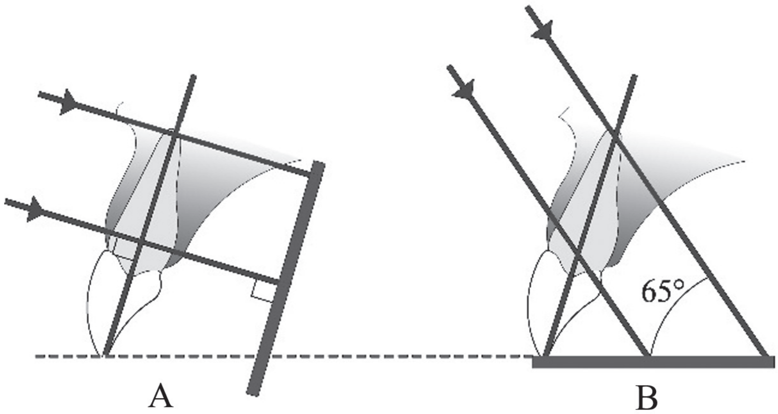

Figure 14. Diagram showing the difference in vertical angulation of the X-ray tubehead.

A. For a paralleling technique periapical;
B. An upper standard occlusal of the maxillary incisors.

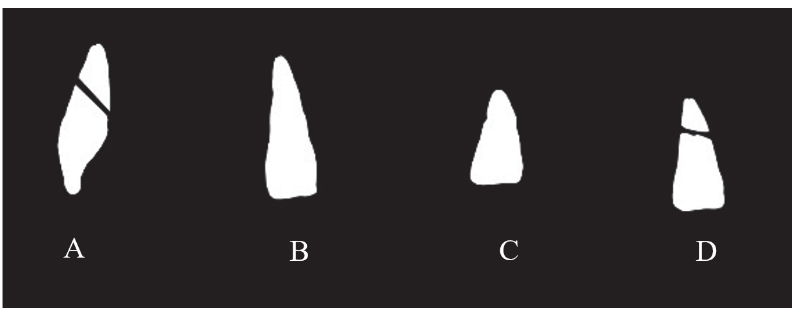

Figure 15. The different radiographic appearances of a oblique root fracture using different projections.
A From the side showing the direction of the fracture and separation of the fragments;
B. using a horizontal X-ray beam;
C. using an angled (75°) X-ray beam;
D. using an angled (65°) X-ray beam.

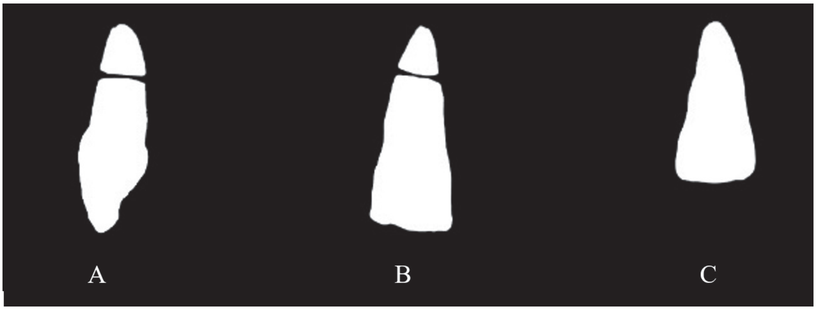

Figure 16. The different radiographic appearances of a horizontal root fracture.
A. From the side;
B. Using a horizontal X-ray beam;
C. Using an angled (65°) X-ray beam.

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Chapter 6

RADIODIAGNOSTIC APPROACH TO TRAUMATOLOGY IN PEDIATRIC DENTISTRY PART 2

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In the first part of radiodiagnostic approach to traumatology in pediatric dentistry; injuries to the hard dental tissues were discussed. In the second part; injuries to the periodontal tissues, injuries to supporting bone and injuries to gingiva or oral mucosa will be discussed. In order to remind, the trauma classification (World Health Organization, 1995; Andreasen, Andreasen & Andersson, 2007) is listed below.

1. Injuries to the Hard Dental Tissues and the Pulp

- Enamel Infraction
- Enamel Fracture (Uncomplicated Crown Fracture)
- Enamel Dentin Fracture (Uncomplicated Crown Fracture)
- Complicated Crown Fracture (Enamel Dentin Pulp Fracture)
- Uncomplicated crown root fracture (Crown Root Fracture without Pulp Exposure)
- Complicated Crown Root Fracture (Crown Root Fracture with Pulp Exposure)
- Root fracture

2. Injuries to the Periodontal Tissues

- Concussion
- Subluxation
- Extrusive Luxation
- Lateral Luxation
- Intrusive Luxation
- Avulsion

3. Injuries to Supporting Bone

- Comminution of the Maxillary Alveolar Socket
  Comminution of the Mandibular Alveolar Socket

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- Fracture of the Maxillary Alveolar Socket
  Fracture of the Mandibular Alveolar Socket
- Fracture of the Maxillary Alveolar Process
  Fracture of the Mandibular Alveolar Process
- Fracture of the Maxilla
  Fracture of the Mandible

4. Injuries to Gingiva or Oral Mucosa

- Laceration of Gingiva or Oral Mucosa
- Contusion of Gingiva or Oral Mucosa
- Abrasion of Gingiva or Oral Mucosa

2. INJURIES TO THE PERIODONTAL TISSUES

Radiographic inspection of luxated teeth gives information about the extent of injury to the root-periodontal ligament and alveolar process. Besides, vitality of the pulp may be assessed. Initial radiographs provide a comparison for follow-up examinations of affected tooth. (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014)

Concussion

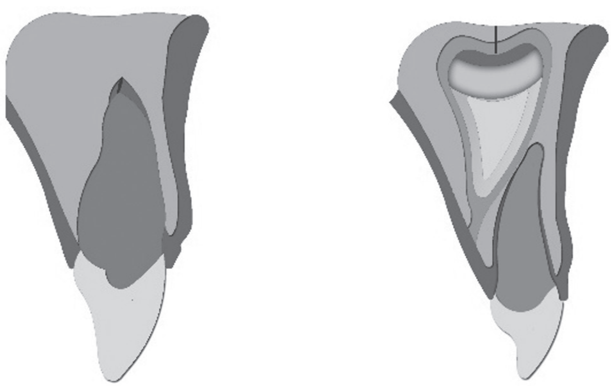

Figure 1. Diagram illustrating the concussion of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for concussion (Figure 1) in order to eliminate the possible presence of more severe luxation injuries and root-alveolar fractures. Generally, normal radiographic signs are observed (Figure 2) (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008). Localized small widening of the apical periodontal ligament space may be assessed. In months and years after trauma, size of the pulp chamber and root canals may change radiographically.

Teeth that have subjected to trauma before apical closure may develop in months and years, a morphologically abnormal apex named ‘osteodentin cap’. It may resemble bone and it caps the end of the root. The development of the root canal and deposition of dentin is ‘frozen in time’ at the developmental stage at which pulpal necrosis occurred. And, the root canal seen in association with an osteodentin cap appears uniformly widened from pulp chamber to apex (White & Pharoah, 2014).

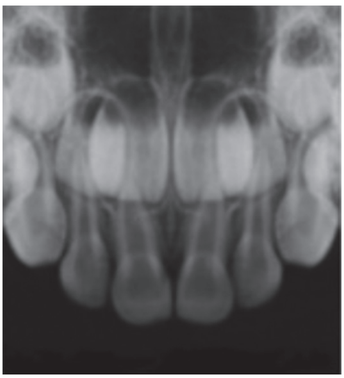

Figure 2. Concussion of tooth 51. No abnormal changes are seen in the radiography.

Subluxation

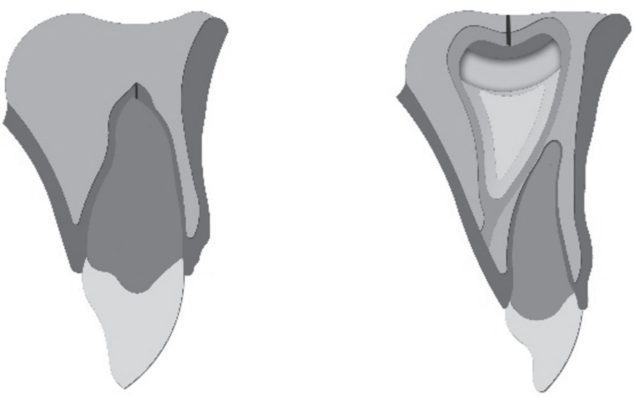

Figure 3. Diagram illustrating the subluxation of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for subluxation type injuries (Figure 3) in order to eliminate the possible presence of more severe luxation injuries and root-alveolar fractures and observe the widening of the apical portion of the periodontal ligament space (Figure 4a-b, 5a-b). Nevertheless, elevation of the tooth may not always be apparent on the radiograph. Initial radiographs provide a comparison for follow-up examinations of affected tooth (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014).

In months and years after trauma, size of the pulp chamber and root canals may change radiographically. As with dental concussion, teeth that have subjected to trauma before apical closure may develop osteodentin cap in months and years (White & Pharoah, 2014).

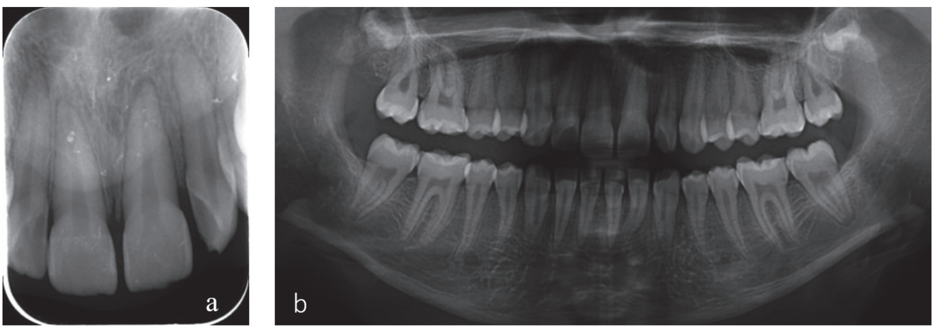

Figure 4a-b. Subluxation of tooth 21 of a 13 years old girl. Note the increases to the widths of the apical periodontal ligament spaces.

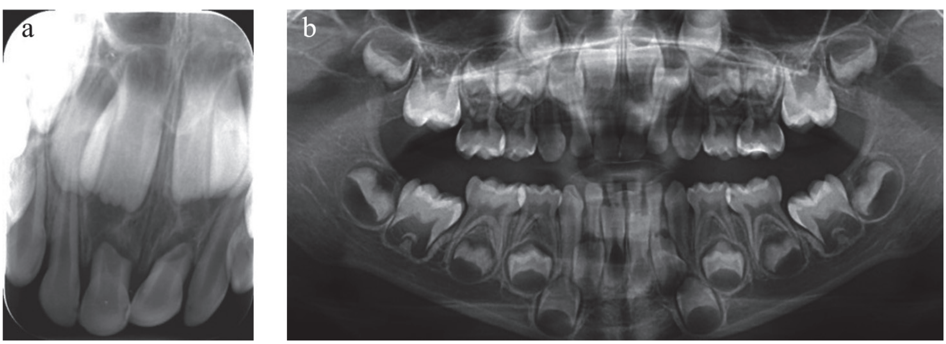

Figure 5a-b. Subluxation of teeth 51, 61 of a 6 years old boy. Note the increases to the widths of the apical periodontal ligament spaces.

Extrusive Luxation

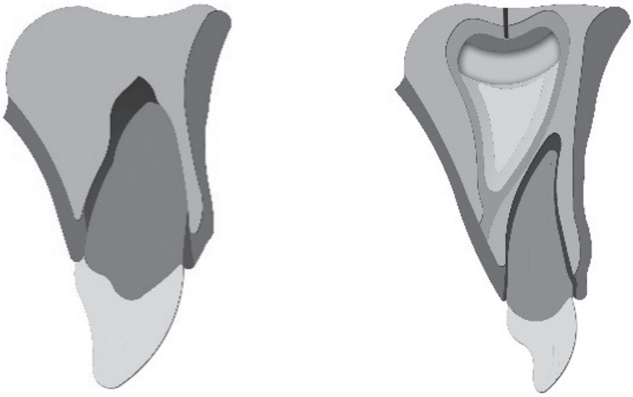

Figure 6. Diagram illustrating the extrusive luxation of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for extrusive luxation injuries (Figure 6). Depending on the extent of the extrusive force, varying degrees of apical widening of the periodontal ligament space is observed and also possible root and alveolar fractures are eliminated by the radiographic inspection (Figure 7) (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014).

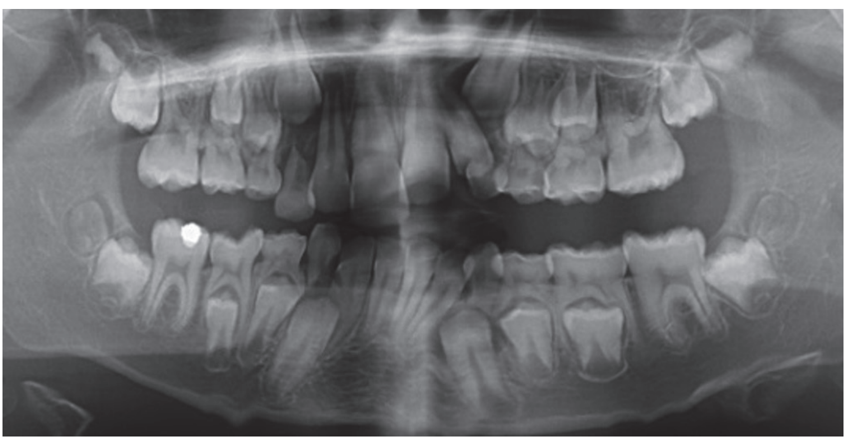

Figure 7. Extrusive luxation of tooth 11 of 10 years old girl.

Lateral Luxation

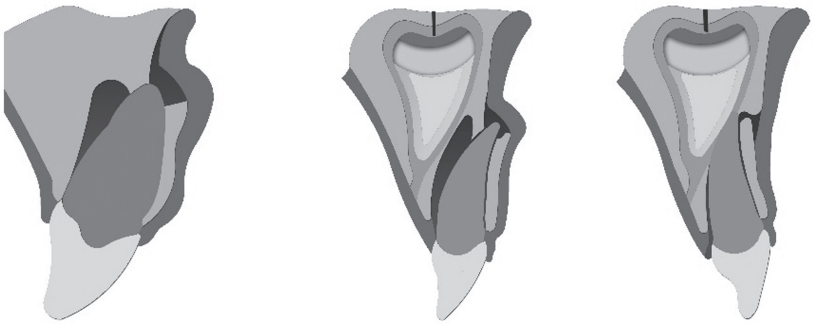

Figure 8. Diagram illustrating the lateral luxation of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for lateral luxation injuries (Figure 8). Varying degrees of widened periodontal ligament space is observed on the images (Figure 9a-b, 10). Periodontal ligament space is best seen on the occlusal exposure. And an occlusal exposure can sometimes also show the position of the displaced primary tooth and its relation to the permanent germ. Besides, possible root and alveolar fractures are eliminated by the radiographic inspection (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014).

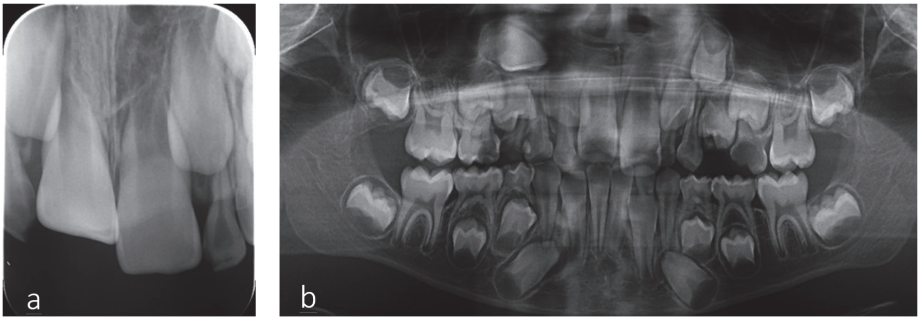

Figure 9a-b. Lateral luxation of tooth 21 and intrusive luxation of tooth 11 of 7 years old boy.

Figure 10. Lateral luxation of tooth 51 of a 5 years old boy.

Intrusive Luxation

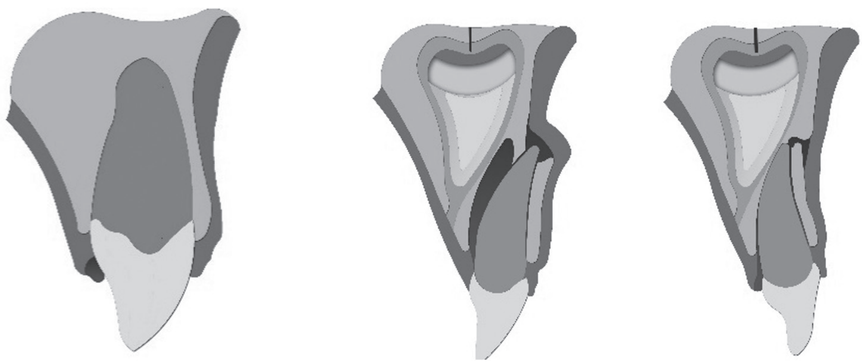

Figure 11. Diagram illustrating the intrusive luxation of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs and images taken from different angles are recommended for intrusive luxation injuries (Figure 11) (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008). The depressed location of the crown of the intruded tooth is often visible on the radiographs (Figure 12a-b), although minimally intruded tooth may be difficult to identify (White & Pharoah, 2014). The cemento-enamel junction is positioned more apically in the intruded tooth than in adjacent non-injured teeth. Intrusion may result in partial or total obliteration of the periodontal ligament space. Furthermore, direction of tooth displacement, relationship of the intruded tooth to adjacent teeth and the outer cortex of bone, possible root and alveolar fractures are inspected by the radiographic inspection. In primary teeth, when the apex is displaced toward or through the labial bone plate, the apical tip can be visualized and appears shorter than its contra lateral. When the apex is displaced towards the permanent tooth germ, the apical tip cannot be visualized and the tooth appears elongated. The cemento-enamel junction is positioned more apically in the intruded tooth than in adjacent non-injured teeth (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014).

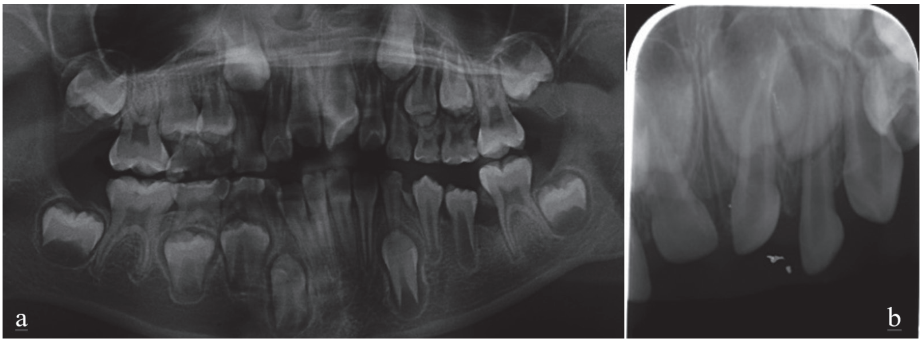

Figure 12a. Intrusive luxation of teeth 11 and 21 of a 9 years old boy. **b.** Intrusive luxation of teeth 51 and 61 of a 3 years old boy.

Avulsion

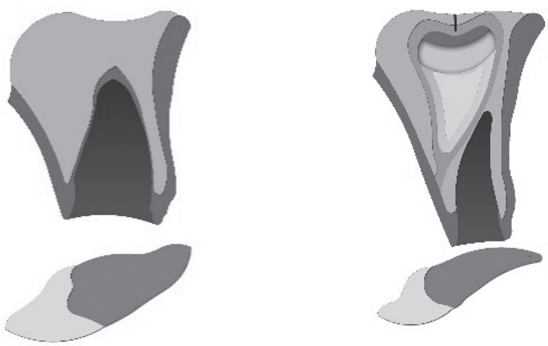

Figure 13. Diagram illustrating the avulsion of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs, images taken from different angles and radiographs of soft tissues (lip, tongue) are recommended for avulsion injuries (Figure 13). Radiographic examination is important to ensure that the missing tooth is not intruded and to eliminate the possible root and alveolar fractures (Andersson & al., 2012; Malmgren & al., 2012). The missing tooth may also be displaced into the adjacent soft tissue and its image may superposition over the image of the alveolar bone, giving the false impression that it lies within the bone. To make the differential diagnosis between the intruded and avulsed tooth that is lying in the soft tissues, radiograph of lacerated lip or tongue should be taken.

In an avulsion case, the lamina dura of the empty socket is visible (Figure 14a-b, 15) and usually persists for several months. In some cases, new bone within the healing socket may be very dense and mimic a retained root tip (White & Pharoah, 2014).

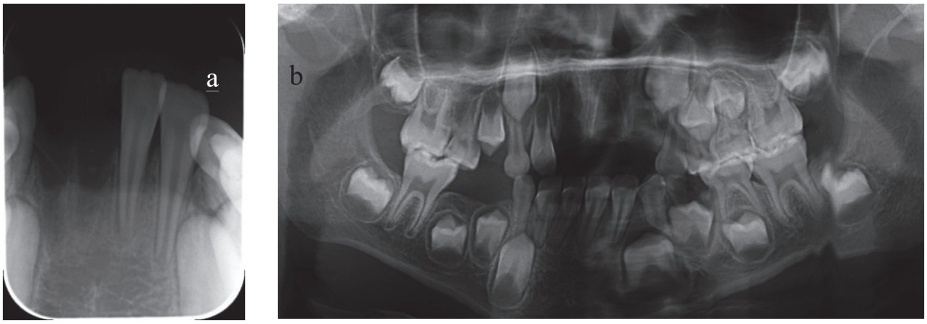

Figure 14a. Avulsion of teeth 41 and 42 of a 9 years old boy. **b.** Avulsion of teeth 11, 21 and 22 of a 8 years old boy.

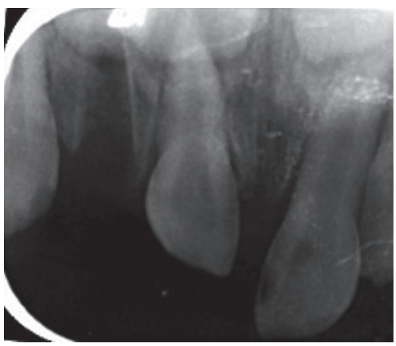

Figure 15. Avulsion of tooth 52 and intrusive luxation of tooth 51 of a 4 years old boy.

3. INJURIES TO SUPPORTING BONE

- Comminution of the maxillary alveolar socket
  Comminution of the mandibular alveolar socket
- Fracture of the maxillary alveolar socket
  Fracture of the mandibular alveolar socket
- Fracture of the maxillary alveolar process
  Fracture of the mandibular alveolar process
- Fracture of the maxilla
  Fracture of the mandible

Alveolar Fracture

Alveolar Fracture

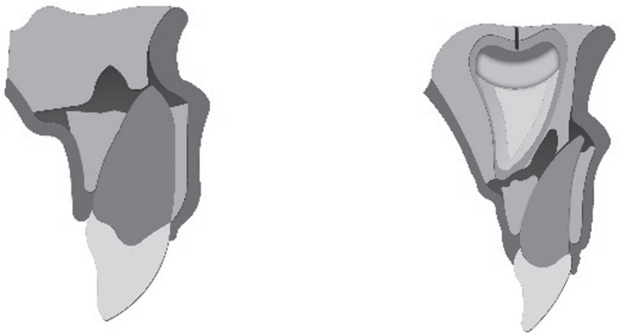

Figure 16. Diagram illustrating the alveolar fracture of both the permanent and primary teeth.

Periapical and occlusal radiographs, panoramic radiographs, images taken from 3 different angles and small volume CBCT images are recommended for determining the alveolar fractures (Figure 16). Fracture lines may be positioned at any level, from the marginal bone to the root apex (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008; White & Pharoah, 2014). Fractures may be visualized as a small radiolucent line radiographically (Figure 17) (Ghom & Ghom, 2016). Initial radiographs provide a comparison for follow-up examinations. In primary teeth the horizontal fracture line to the apices of the primary teeth and permanent germs will be disclosed. A lateral radiograph may also gives information about the relation between the two dentitions and if the segment is displaced in labial direction (DiAngelis & al., 2012; Malmgren & al., 2012; Cameron & Widmer, 2008).

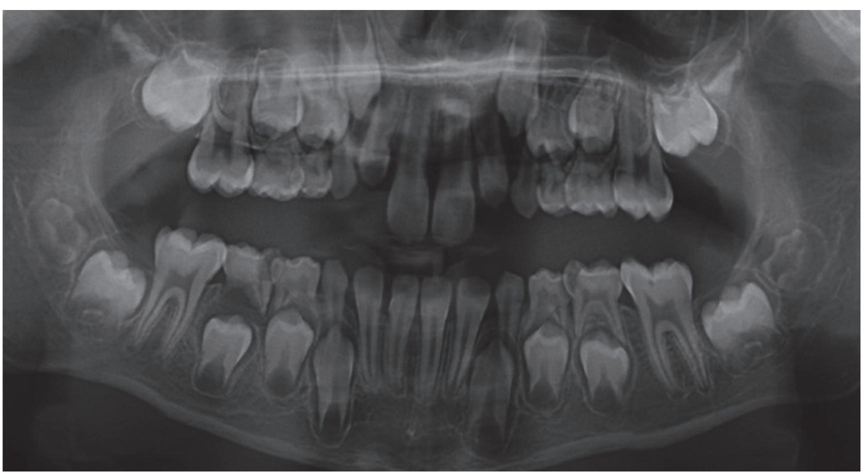

Figure 17. Alveolar fracture on maxilla is observed.

Fracture of the Maxilla

This is probably one of the most difficult topics in dental radiology. Owing to the complexity of the facial skeleton, there is a fundamental need for a sound knowledge of anatomy.

Le Fort's type I (bilateral detachment of the alveolar process and palate, or the low-level subzygomatic fracture of Guérin), Le Fort's type II (pyramidal, subzygomatic fracture of the maxilla) and Le Fort's type III (high-level suprazygomatic fracture of the central and lateral parts of the face) fractures are the fracture types of the middle third of facial skeleton that include fractures of the maxilla (Whaites & Drage, 2013). Although Le Fort fractures may be bilateral, they are mostly unilateral. Besides these fracture types, fractures of the zygomatic complex, fractures of the naso-ethmoidal complex and fractures of the orbit may also be seen together with the maxilla fractures.

Cause CT/CBCT imaging provides multiple image slices in orthogonal planes through the face allowing for the display of osseous structures without the complication of overlapping anatomy that is problematic with plain imaging, it is the diagnostic imaging method of choice for complex facial fractures. CT/CBCT also provides suitable image detail to diagnose secondary changes associated with trauma, including herniation of orbital fat and extraocular muscle, soft tissue swelling or emphysema, and blood or fluid accumulation. CT/CBCT images may be reformatted to three-dimensional images (Figure 18) (White & Pharoah, 2014; Ozdede & ark).

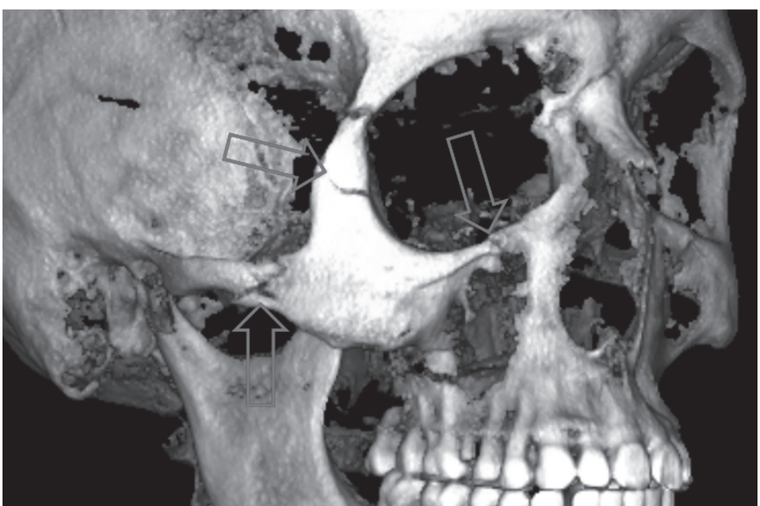

Figure 18. Maxillofacial fractures on 3D reconstruction image of CBCT. Fractures on the right zygomatic arch and orbital fractures.

Le Fort I

This type of fracture (Figure 19) is identified on panoramic radiograph, posteroanterior radiograph, lateral skull, 0° occipitomental, 30° occipitomental radiographs and Water projections. Lateral view shows slight posterior displacement of fragment.

CT/CBCT imaging reveals an air-fluid level or radiopacification in the maxillary sinus. Coronal images may reveal the plane of the fracture extending posteriorly through the maxilla, whereas coronal or axial images together may reveal involvement of the pterygoid plates posteriorly. CT/CBCT images may be reformatted to three-dimensional images and may show the plane of the fracture to greatest (Ghom & Ghom, 2016; White & Pharoah, 2014; Whaites & Drage, 2013).

Le Fort II

This type of fracture (Figure 19) is identified on lateral skull, 0° occipitomental, 30° occipitomental radiographs.

Deformities and discontinuation of lateral walls of both sides of maxillary sinus can be examined. Thickening of the lining mucosa and clouding of maxillary sinus are also visible. CT/CBCT imaging is the modality of choice for imaging. The radiologic examination reveals fractures of the nasal bone, frontal process of the maxilla, infraorbital rim, and orbital floor (Ghom & Ghom, 2016; White & Pharoah, 2014; Whaites & Drage, 2013).

Le Fort III

This type of fracture (Figure 19) is identified on lateral skull, 0° occipitomental, 30° occipitomental radiographs and especially CT/CBCT coronal and sagittal scans. Three-dimensional reconstructions of CT/CBCT images show the fracture planes and the large bone fragments Separation of sutures like, nasofrontal process, maxillofrontal, zygomaticofrontal and zygomaticotemporal, can be visualised. Nasal bone, frontal process of maxilla, both orbital floors and pterygoid plate may show radiolucent lines and discontinuity. Ethmoidal and sphenoid sinuses seem cloudy (Ghom & Ghom, 2016; Whaites & Drage, 2013).

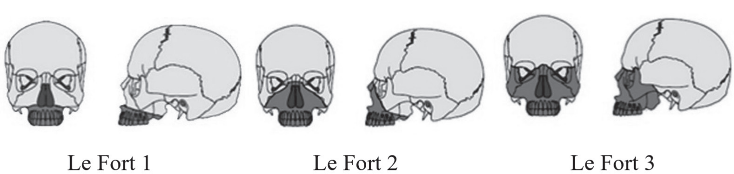

Figure 19. Diagrams of the skull from the front and side showing the main sites of middle third facial fractures.

Fracture of the Mandible

Several different images are used to show the various mandibular fracture sites (Figure 20). The radiographic examination of a suspected mandibular fracture may include panoramic imaging or CT imaging. Panoramic imaging may be useful as an initial investigation for assessing mandibular fractures. Additionally, in some cases, if the patient is cooperative and conscious, intraoral periapical and occlusal radiographs may be useful. The ideal minimum need in all cases is two views at right angles to one another. If that is not possible, two views at two different angles should be used. CBCT (Figure 21) or multidetector computed tomographic imaging (MDCT) may be required. Magnetic resonance imaging (MRI) may be useful to assess soft tissue injury to the temporomandibular joint capsule or articular disk (Whaites & Drage, 2013; White & Pharoah, 2014).

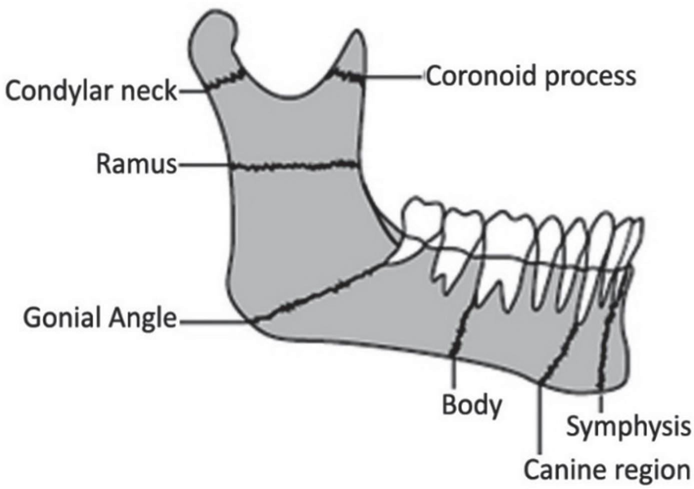

Figure 20. Diagram showing the fracture sites of the mandible.

The radiographs that can be used for the different mandibular fracture sites are listed below (Whaites & Drage, 2013; Ghom & Ghom, 2016):

Angle of the mandible: Panoramic radiograph or oblique lateral, posteroanterior radiograph.

Condyle: Panoramic radiograph or oblique lateral, posteroanterior radiograph (for low condylar neck fractures), Reverse Towne' s (for high condylar neck fractures). Transcranial and transorbital view of TMJ (displacement of the high condylar fracture). CBCT is useful for suspected central dislocation of the condyle through the glenoid fossa.

Body: Panoramic radiograph or oblique lateral, posteroanterior radiograph, periapicals of involved teeth, lower 90° occlusal radiograph.

Canine region: Panoramic radiograph or oblique lateral, periapicals of involved teeth, true lateral skull.

Symphisis: Lower 45°, lower 90° occlusal radiograph.

Ramus: Panoramic radiograph or oblique lateral, posteroanterior radiograph.

Coronoid process: Panoramic radiograph or oblique lateral, 0° occipitomental radiograph.

While doing the overall critical assessment, it is worth remembering that many patients who have recently been injured may be very difficult to radiograph because of pain, medication, overlying soft tissue wound dressings or other injuries which they may have sustained at the same time. In addition, blood in the antra, nose and pharynx may adversely affect film contrast (Whaites & Drage, 2013).

Figure 21. Left angulus mandible fracture on the coronal section of CBCT.

The typical radiographic features of mandibular fractures may include, radiolucent line(s) between the bone fragments if they are separated. Two radiolucent lines may be seen through the buccal and lingual cortical plates. A radiopaque line is seen if the fragments overlie one another. Displacement of the fragments result in a cortical discontinuity or step or an irregularity in the occlusal plane (Figure 22). If the fracture involves a tooth socket, widening of the periodontal ligament space may be seen. If an unerupted tooth is involved in the fracture, tooth follicle may be enlarged. An incomplete fracture that usually occur in children, involving only one cortical plate is often called a greenstick fracture (Whaites & Drage, 2013; White & Pharoah, 2014).

The position and severity of the fracture, degree of separation of the fragments and the position of the film and X-ray tubehead in relation to the fracture lines, are the the limitations that can influence the appearence of the radiographic image (Figure 23). It is because of these limitations that at least two images, at different angles, are required (Whaites & Drage, 2013).

Figure 22. Diagrams illustrating the radiographic appearances of fracture displacement and fracture overlapping.

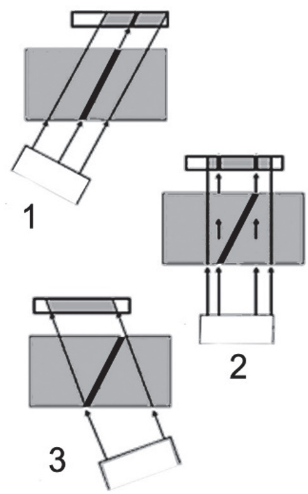

Figure 23. Diagrams illustrating how the position of the film and X-ray tubehead in relation to a fracture can affect the final image.

4. INJURIES TO GINGIVA OR ORAL MUCOSA

When the patient has lip and cheek lacerations and when the fractures of enamel, enamel-dentin, enamel-dentin-pulp, crown-root or avulsion occured, periapical radiographs of lip and cheeks should be taken to search for tooth fragments or foreign materials (Figure 24) (Malmgren & al., 2012; Agrawal& al., 2005).

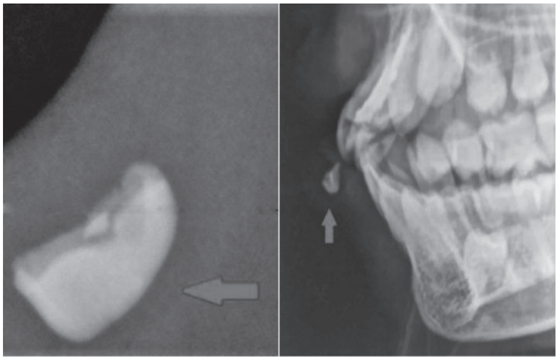

Figure 24. Arrow showing fracture fragment of tooth in lower lip (Agrawal& al., 2005)

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Chapter 7

SURGICALLY ASSISTED RAPID MAXILLARY EXPANSION

Sanaz SADRY[1]

INTRODUCTION

While the skeletal problem is resolved with apparatus which provide maxillary and midpalatal sutural expansion in growing patients, this procedure is not successful in skeletally matured patient. Therefore surgically assisted rapid maxillary expansion (SARME) is suggested to reduce the circummaxillary sutural resistance to correct maxillary width deficiencies.

The aim of this review was to evaluate effects of surgically assisted rapid maxillary expansion treatment in orthodontics. In this review, we will point out the description of RME, indication, history, advantages and complications, go about the methods of procedure and deal with the differences from RME.

Surgically assisted rapid maxillary expansion

Rapid maxillary expansion (RME) is the procedure of opening the midpalatal suture by applying force on the tooth and/or palatal mucosa in lateral direction that exceeds the limitations of tooth movement. RME plays an important role in dentofacial therapy in bringing the maxilla displaying transversal stenosis to its ideal size. Transversal growth restriction of the maxilla may occur due to genetic or environmental reasons. One of the most common causes of this is seen in individuals with oral respiration, where the tongue is positioned on the floor of the mouth, causing the buccinator mechanism to deteriorate and buccinator muscles to form stenosis in the maxilla (2). SARME shows clinical success in patients with complete growth by providing a visible expansion; however, this treatment option fails to eliminate tipping and extrusion movement in anchored teeth (3). Compared to surgical options, expansion of the maxilla is an unstable process. In order to increase the stability, surgically assisted RME is promoted over RME.

History of surgically assisted rapid maxillary expansion

Since Angell's (5) first case where he performed maxillary correction in transverse deficiency, various surgical procedures have been suggested. The term

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'rapid expansion' was first defined by Haas (6, 7) as a technique used to correct maxillary stenosis. Haas speculated that the major reason of the failures in this procedure was due to insufficient expansion. Thus, he suggested over expansion to prevent relapse. Midpalatal suture had long been thought as the main cause of the resistance that occur during maxillary expansion; but Isaacson and Murphy (8) and Isaacson et al. (9) proved that other sutures also plays a significant role in the resistance during maxillary expansion. Haas (7) argued zygomaticomaxillary suture to be the suture with the highest resistance. Lines (10) and Bell et al. (11), on the other hand, argued that it was zygomaticotemporal, zygomaticofrontal and zygomaticomaxillary sutures offer the main resistance during maxillary expansion. Wertz (12) proposed the theory that the entire resistance that occur during maxillary expansion would come from zygomatic arch. These opinions played an important role in the development of various osteotomy lines that can be used during surgical application. Steinhauser (13), defined osteotomy lines that are similar to ones used in the Le Fort I technique and filled the cavities with bone grafts.

Indications of surgically assisted rapid maxillary expansion

Common indications of surgically assisted rapid maxillary expansion;

1. Skeletal maturity, in growing and adult individuals
2. Unilateral or bilateral transversal maxillary hypoplasia
3. Anterior crowding
4. Buccal corridors called black corridors occurring during smiling
5. Cases where orthodontic maxillary expansion fails due to resistance of sutures.
6. Patients with cleft palate (14).

In skeletally matured patients, unilateral and bilateral transversal hypoplasia can be corrected with SARME. Space is provided in the dental arch for tooth alignment through a treatment including surgical and orthodontic applications. This approach also provides a satisfactory expansion in the apical base and palate depth of the maxilla, thus providing effective space for proper swallowing, thus preventing relapse. Additionally, an increase in the nasal breathing is observed in relation to the expansion in the space.

Methods of surgically assisted rapid maxillary expansion

Surgically assisted rapid maxillary expansion methods are categorized as follows (15):

1. Bilateral maxillary surgery or subtotal Le Fort I osteotomy
2. Bilateral posterior maxillary surgery

3. Unilateral posterior maxillary surgery
4 Palatal osteotomy application in addition to lateral maxillary osteotomy

SARME and Le Fort I

In circular crossbite cases, surgical application is aimed at the entire maxilla (15). Before surgery, the apparatus is attached to the mouth. At the vestibular sulcus base, incision is made from the first molar region on one side to the midline, and another incision is made at the cortical bone from the piriform aperture to the pterygoid fissure. This application is defined as lateral maxillary osteotomy. Furthermore, a vertical incision is made between centrals through the attached gingiva and mucosa through to allow midpalatal osteotomy. Suture is separated from under the anterior nasal spin via osteotome (16). The osteotome is moved to right and left until a 2-3 mm space is formed between the central incisors. Further space cannot be formed due to the presence of the expansion apparatus. After the surgery, the apparatus is activated before soft tissues are stitched and a 4-5 mm expansion is provided. If asymmetric expansion is detected during this time, the osteotomy lines should be rechecked (15). Surgical application of surgically assisted rapid maxillary expansion comprises subtotal Le Fort I osteotomy. Subtotal Le Fort I osteotomy can be summarized as follows (17):

1. Bilateral osteotomy from the piriform rim towards the pterigomaxillary fissure (osteotomy should be parallel to the maxillary occlusal plane)
2. Separation of nasal septum from maxilla
3. Performing midpalatal osteotomy with an osteotome
4. Osteotomy of the anterior 1.5-mm part of the lateral wall of the nasal cavity (separation of the lateral wall of the nasal cavity from the posterior is not needed as it has been reported to not show any resistance to the lateral movement of the maxilla)
5. Separation of the bilateral tuber maxilla from the pterygoid plate (pterygoid process is adjacent to the sphenoid bone, a single bone on both sides. Therefore, maxilla should be separated from the pterygoid process to leave room for posterior maxillary expansion)
6. Activation of the maxillary movement on both sides and activation of the apparatus to provide a total expansion of 1-1.5 mm
7. Suturing soft tissues

Bilateral posterior maxillary surgery

In patients with bilateral posterior crossbite, if the distance between the canines is sufficient and minimal anterior crowding and protrusion are present, surgical application is recommended only to the posterior of the maxilla since performing surgery on the entire maxilla will result in unnecessary effort and the canine relationship will have to be reestablished. This practice is not necessary before the eruption of permanent canines (15). The apparatus should be attached to the mouth before surgery. In the application defined as lateral buttress osteotomy, the mucoperiostal incision is made from the maxillary canine region to the posterior or below the zygomatic maxillary buttress from the 1st molar mesial to the distal part of the canine tooth. After the bone is exposed, horizontal osteotomy is performed 5 mm above the dental apex from piriform rim to maxillary buttress. The maxillary sinus is exposed during this time. Then, the direction of the bone incision continues from the zygomatic maxillary buttress to the pterigomaxillary fissure. Osteotomy extends to the posterior and inferior of the pterigomaxillary fissure. At the final stage, the tuber maxilla is separated from the pterigod plate (18, 19).

Unilateral posterior maxillary surgery

The unilateral surgically assisted RME is applied to the posterior of the maxilla and is performed in cases of true unilateral posterior maxillary deficiency (15). During surgery, the incision is made from the molar region to the canine area in the vestibular sulcus. The apparatus is first cemented to the mobilized segment, followed by the other stable segment (15). When surgically assisted RME is performed unilaterally, the other side is used as anchorage (20). After 2-3 mm activation is achieved following cementation, the incision line is sutured (15).

Palatal osteotomy application in addition to lateral maxillary osteotomy

Several academics argued that an additional surgical procedure on the palate is required to provide palatal expansion (21). Nortway (21) raised the U-shaped palatal flap and performed incision from the incisive foramen to the spina nasalis posterior.

In a case where Gorback (22) performed median palatal osteotomy assisted RME, he raised the palatal flap from the upper second premolar to the second molar on the other side. This application ensures a clear view of the palatal suture and the continuation of blood build-up; however, there is a possibility of damage to the nasopalatine nerve within the incisive canal. However, no permanent paresthesia was observed. After the surgery, palatal stent placed on the palate was removed 2 days later and it was reported that expansion was initiated by placing the apparatus.

Advantages of surgically assisted rapid maxillary expansion

When a skeletal stenosis is detected in the maxilla, the treatment option should be to provide a skeletal expansion of the upper jaw by separating the midpalatal suture. Patient age is one of the most important factors affecting the success of rapid maxillary expansion. Rapid maxillary expansion techniques can be applied in patients in growth period, while surgically assisted rapid maxillary expansion is preferred in adolescents and young adults where whose growth periods have stopped (23). Surgically assisted RME applied in the correction of severe transverse maxillary discrepancy is a simple, highly effective and stable method (24, 25, 26). The surgery reportedly helps reduce the connections between the maxilla and the surrounding structures, maintain periodontal health, and decrease the risk of resorption in the roots that exert the expansion forces (27). Surgical-assisted RME does not only increase the distance between the molars and the palatal width, but as reported in some cases, nasal breathing also improves (21).

Complications of surgically assisted rapid maxillary expansion

Surgically assisted rapid maxillofacial expansion (SARME) is generally reported to have a lower morbidity rate when compared to other orthognathic surgical procedures (Bays et al., 1992). However, various complication risks are still present. For that reason, the surgeon and the orthodontist should keep these in mind before SARME is recommended to the patient. Complications associated with SARME as reported in the literature are listed as follows; severe hemorrhage, gingival recession, (28) root resorptions, damage to the branches of the maxillary nerve, infection, pain, devitalization of the teeth and pulpal blood flow changes, periodontal disorders, sinus infection, extrusion of the teeth on which the apparatus is placed, relapse and unilateral expansion. In addition to these, there are other complications related to the expansion device such as; palatal soft tissue irritation, loosening and fracture in the apparatus, or locking of the apparatus screw (29). Palatal tissue irritation is one of the most common complications of SARME. This may be due to irritation caused by the apparatus, or rapid expansion performed in a way that does not allow soft tissue histogenesis. The incidence of aseptic tissue necrosis was reported as 1.8%, and palatal mucosal ulcerations were reported in at least 5% of the patients (29). Hemorrhage can be life-threatening, and also may require blood transfusion and hospital conditions (30).

Unexpected fractures may occur in the maxilla from time to time. Fractures are not rare occurrences as they are areas that can offer resistance. Increased mobility, gingival recession, gingival ruptures and defects may be observed as a result of the asymmetric fracture of the interdental bone between the central incisors (31). Rare complications such as transient blindness, bilateral lingual anesthesia and nasopalatine channel cyst have also been reported (29). Like every surgical procedure, SARME too comes with various risks. Therefore, careful planning and application is necessary to get the most efficient results (29).

Effects of surgically assisted rapid maxillary expansion

It was found out that 50% of the maxillary expansion is skeletal and the rest is dentoalveolar. The loss of one-third of maximum expansion in prepubescent children and adolescents may be caused by non-surgical rapid maxillary expansions. The amount of recurrence in dental arch widening after surgically assisted RME is the same as non-surgical RME in young patients, but the difference between them lies in the greater stability of the skeletal changes caused by surgically assisted RME (32, 23).

Dental and skeletal expansion

According to Chamberland and Proffit (33), the width of the midline diastema at the maximum expansion point is in relation with the first molar width. The formation of diastema is indicative of a sufficient molar width. When skeletal expansion occurs, there is a low correlation between skeletal and dental changes. This is because the maxillary segments do not expand symmetrically. Instead, as described by Byloff and Mossaz (34) and demonstrated by Chung and Goldman (35), some rotation occurs and the teeth extend more than the underlying bone. The said rotation of the maxillary segments or alveolar bending explains why the skeletal change at the maximum expansion point only comprises 47% of dental expansion. For this reason, the horizontal part of the screw should be 3mm away from the palatal mucosa to prevent contact. Kreps (36), using metal implants, showed that 50% of the RME-related expansion in children was skeletal, while the rest was dentoalveolar. Hansen et al. (37) observed a 91% skeletal expansion in the premolar region and 85% in the molar region. According to Chamberland and Proffit (33), the expansion in the intermolar region at the maximum expansion point is as much as about half of the skeletal expansion related to SARME. At this point, dental relapse occurs. But skeletal expansion is stable. At the end of the treatment, two-thirds of the net enlargement is observed to be skeletal. Handelman et al. (38) compared non-surgical RME in young and old patients. They estimated a 18% skeletal expansion in adults and 56% in adolescents. Bacetti et al. (39) had a skeletal expansion of only 0.9 mm in patients in peak and post-peak period, who underwent RME. On the other hand, they achieved a skeletal expansion of 3 mm in pre-peak patients.The nature of the expansion achieved by RME in adult patients who are candidates for SARME displays a shift from skeletal to dentoalveolar. Changes involving dental movements at the alveolar level have been proven to be periodontally harmful (21). In the study carried out by Chamberland and Proffit (33), the skeletal expansion achieved with SARME is highly stable. The recurrence can be characterized as the lingual movement of the posterior teeth. The achieved expansion is reportedly 2 mm greater than what has been previously desired. In SARME patients with a desired expansion of 7-8 mm in the first molar region, an extra expansion of 2 mm has been reportedly indicated. This amount is required to compensate for the buccal tipping during expansion of the posterior segment.

Effects of SARME on the upper respiratory tract

Transversal maxillary stenosis associated with isolated or other dentofacial deformities results in functional and aesthetic defects, such as nasal blockage and high-arch palate that leads to oral respiration, or difficulty in chewing due to bilateral or unilateral transversal stenosis (27, 6). Maxillary stenosis and the associated high palatine vault are the two features of the skeletal development syndrome. Laptook (40) rounded up the other features of this syndrome as follows;

1. Decreased nasal permeability due to nasal stenosis
2. Elevated nasal base
3. Oral respiration
4. High palatine vault and bilateral dental maxillary crossbite
5. Dimension reduction in the nasal airway due to enlarged nasal folds

A maxilla with sufficient transverse dimensions is an important component for stable and functional occlusion (41). Orthopedic rapid palatal expansion is a preferred procedure for the correction of skeletal immaturity in patients with said condition. However, as the skeletal maturity approaches, bone interdigitations such as the fusion of sutures were increases (42). Therefore, it is difficult to separate the maxilla using only orthopedic forces and it leads to alveolar bending, buccal tipping of the teeth and minimal maxillary expansion. This results in pain, periodontal defect (significant gingival recession), pressure in the periodontal ligament, malocclusion, and relapse despite overcorrection (23, 27, 7).

A comparison of rapid maxillary expansion and surgically assisted rapid maxillary expansion

In terms of clinical results, no significant difference was observed in patients who underwent RME and SARME (43). Indications are made depending on age and skeletal development. In both applications, long-term follow-up of maxillary arch width is of great importance. The most significant difference between the two applications cephalometrically is maxilla's tendency to rotational movement. No significant rotation is observed in the maxillary plane as the sutural resistance is eliminated against the expansive forces in SARME. SARME is a successful treatment option in adult patients with transversal maxillary insufficiency (43).

Retention, stability and relapse

Most articles in the literature argue that SARME is more stable than RME (29 ,43, 23, 21). Some authors are of the opinion that retention is not necessary after SARME and that orthodontists can start orthodontic treatment without any waiting time (23), while some others recommend a period of retention ranging from 2 to 12 months after expansion (21). In SARME, the relapse rates vary between 5-25%. Considering the fact that relapse can be as high as 63% in RME, these rates can be considered quite low. The reason for such high rate of relapse in RME is associated with its application on patients with advanced skeletal development. RME is an unstable procedure in patients with advanced age (29). Most studies argued that relapse in SARME is a condition that should be taken into consideration by clinicians, yet reported a low incidence of relapse (44).

Conclusion

SARME is a good treatment alternative in adult patients who have completed their growth and development, and are not eligible for RME. Used in correction of transversal deficiencies, this technique is considered as a clinically effective and stable approach. Compared to RME, SARME maintains periodontal health, decreases the risk of resorption in the roots and increases the long-term stability.

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Chapter 8

CURRENT PERSPECTİVES OF APICAL RESECTION

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APICAL RESECTION

Apical resection (apiceoctomy) involves the removal of the affected apical portion of the tooth and the curetage of all necrotic and inflamed tissue in the periapical region. Conventional endodontic treatment has a high success rate, however failures have also been observed and retreatment may be indicated. In cases where retreatment is not feasible or fails again endodontic surgery may be preserve the tooth (Mandava et al 2015, Jain et al 2016).

The aim of endodontic surgery is to fill the exposed root canal system and isthmuses, eliminating bacteria and preventing their byproducts polluting the periradiculer tissues, providing an environment for regeneration of periradicular tissues.

Indications for apical surgery include;

1. Periapical disease associated with a permenant tooth subjected to endodontic treatment, with pain and inflamation
2. A radiotransparent lesion measuring over 8 to 10 mm in diameter (Figure 1)
3. Symptomatic gutta-percha overfilling or presence of a fractured file not removable in orthograde (the blockage proved not to be removable, displacement did not seem possible or the risk of the damage was too great).
4. Persisting or emerging disease following root canal treatment when root canal treatment is not possible
5. Perforation of the root or the floor of the pulp chamber and where it is impossible to treat from within the pulp cavity (Carrilo et al 2008, Sanchez-Torres, Sanchez-Garces and Gay-Escoda 2014, ESE 2016,).

Post-treatment disease following root-canal treatment is most often associated with poor quality procedures that do not remove intra-canal infection (Figure 2).

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This can be corrected with a non-surgical endodontic treatment but if infection remaining in the inaccessible apical areas, extraradicular infection including apically extruded dentin debris with bacteria present in dentinal tubules, true radicular cysts, and foreign body reactions require surgical intervention (Wu, Dummer and Wesselink 2006).

Figure 1. Premolar teeth with apical lesion

Figure 2. Lateral tooth with insufficient root canal treatment and horizontal root fracture

Contraindications for apical surgery include (Von Arx, 2011):

1. The tooth has no function (no antagonist, it does not matter if it is used as a pillar for fixed prosthesis)
2. The tooth can not be restored
3. The tooth has inadequate periodontal support
4. The tooth has a vertical root fracture
5. Uncooperative patient and have a medical history to create a contraindication for surgical procedure

CURRENT TECHNIQUES OF APICAL RESECTION

Surgical Procedure

1- Anesthesia:

Likewise, other oral procedures,articaine 4% with epinephrine 1:100.000 or 1: 200.000; lidocaine 2% with epinephrine 1:50.000 or 1:100.000; or for long-duration anesthesia, bupivacaine %0.5 with epinephrine 1: 200.000 can be used as local anesthetic agents(Haas, 2002, Lieblich, 2014, Sacco, Greenstein & Patel, 2016). The local anesthetics should be given slowly and avoid accumulation in the submucosal region (Sacco, Greenstein & Patel, 2016). Local nerve block administrations provide better pain control during the endodontic surgery. An inferior alveolar nerve block should be administered for posterior mandibular teeth. Local infiltration can be supplemented with nasopalatine nerve block for maxillary anterior teeth and can be administered with posterior superior alveolar nerve block, middle superior alveolar nerve block or infraorbital nerve block for maxillary posterior teeth (Lieblich, 2014, Sacco, Greenstein & Patel, 2016).

2- Flap design:

Several different flap designs including triangular, rectangular, semilunar, submarginal and papillary base preserved flaps, can be used for the endodontic surgery(Lieblich, 2014, Sacco, Greenstein & Patel, 2016). In the recent past semilunar flap used to be the first choice for this procedure among clinicians, however, due to its notable disadvantages thisdesign was banished from clinical use (Abras, 2016). Although this technique provides a quick access to the periapical region, it limits not only full evaluation of root surface but also potential to further extension. Besides, the incision is based mainly on unattached mucosa, not supported by underlying bone, which poses risk of postsurgical defects (Abras, 2016, Lieblich, 2014). Therefore, full thickness mucoperiosteal flap comprising one or two vertical releasing incisions with horizontal marginal incision is preferred currently. Nevertheless, full-thickness flap design may lead to gingival recession in the surgical field and jeopardize aesthetics of subgingival margins of restoration that previously placed. In these cases, alternative flap designs, i.e.,-submarginal or papillary base preserved flaps, should be considered by practitioners (Lieblich, 2014, Pogrel, Kahnberg& Anderson, 2014).

3- Periapical exposure and curettage:

Following the reflection of a full-thickness mucoperiosteal flap with a sharp periosteal elevator, the apical region of tooth can be examined for any pathological perforation of the cortical bone. If the buccal plate overlying apex is intact, a reduced density of bone should be searched. This area will constitute the starting point of theosteotomy.If there isa perforation onthe buccal plate, the osteotomy will be easier. Round and/or fissure burs can be used for surgical bone removal. All osteotomy should be carried out with high-speed handpieces or electrical handpieces under copious irrigation. In both scenarios, the osseous entry should be enlarged to expose at least apical 3 mm of the root (Lieblich, 2014, Sacco, Greenstein & Patel, 2016). At this stage, it is essential to removethe periapical pathologicaltissue to enhance visibility of surgical field and decrease hemorrhage (Lieblich, 2014, von Arx, 2010).

4- Root end resection:

The extent of apical resection is based on the reason for performing the procedure. Generally, 3 mm of the apical rootresection is recommended to remove the apical delta (Lieblich, 2014, Sacco, Greenstein & Patel, 2016, von Arx, 2010). However, in re-surgery cases, teeth with broken instruments lodged in the apical region or teeth with short roots, the amount of root resection should be individually determined. Additionally, the length of resection must be balanced with providing an adequate depth for root-end filling and preservation of favorable crown-root ratio (Sacco, Greenstein & Patel, 2016, von Arx, 2010).

The bevel of root resection is an essential component of this procedure to ensure all apical region responsible for failure has been addressed (Sacco, Greenstein & Patel, 2016). The term of "bevel" describes the remaining surface of root after the removal of apical root end (Stropko, Doyon & Gutmann, 2005). Conventionally, root ends were resected at a 30˚ to 45˚ bevel for enhancing visualization of the apical surface and also,root end cavity preparation. However, this long bevel increasesthe apical leakage due to increased exposure of the dentinal tubules and may lead to failure of the apical surgery (Niemczyk, 2010, Post & et al., 2010). Recently, the ultrasonic surgical tips are recommended for root end preparations. The angled configuration of these instruments requires only a minimal to 0˚ bevel, therefore, fewer dentin tubules are exposed (Niemczyk, 2010, von Arx, 2010).

5- Root end cavity preparation and restoration:

Following the root resection, residual periapical debris should be eliminated by meticulous apical curettage. Then, a retrograde cavity should be prepared (Lieblich, 2012).In the past, rotary instruments were used to formthese cavities. However, due to their straight design, to provide the root end cavity within the confines of the long axis of tooth was not feasible. Therefore, complications including misaligned preparation of cavity and/or perforation of lingual surface could be developed (Sacco, Greenstein & Patel, 2016, Lieblich, 2014, Stropko, Doyon & Gutmann, 2005). Nowadays, ultrasonic tips are used for the root end preparations. The ultrasonic instruments offer several benefits (Bramante & et al., 2010, Rodríguez-Martos& et al., 2012):

- The ultrasonic tips allow clinicians to protect the morphology of the root canal system by following the long axis of the tooth.
- The root resection can be performedalmost perpendicular to the long axis of the tooth which minimizing the apical leakage.
- The root end cavity can be prepared in easy, safeand precise manner.
- The root end cavity can be formed in a smaller diameter and located more centrally.
- Better cleaning of the cavity walls can be ensured by reducing the volume of dentinal residues.

Some important issues are needed to be considered in the root end cavity preparation. A depth of 3 mm within the long axis of the root canal system should beformed with ultrasonic tips for provide sufficient retention for retrograde filling material.Also, all isthmus tissue, if present, should be completely debrided. Because,this groove between two root canalscan contain necrotic materials and jeopardize the success of the procedure (Sacco, Greenstein & Patel, 2016, Stropko, Doyon & Gutmann, 2005).Moreover, during the ultrasonic root end instrumentation, remaining dentine walls should not be weakened to avoid possible microfractures(Gondim& et al., 2003, Sacco, Greenstein & Patel, 2016, Stropko, Doyon & Gutmann, 2005). After the retrograde cavity preparation, suitable filling material is placed to minimize further apical leakage (Lieblich, 2012, Lieblich, 2014, Stropko, Doyon & Gutmann, 2005).

6- Closure and suturing:

Prior to closure of surgical site, copious amount of sterile saline should be used to irrigate the wound to remove debris, blood clots and residual retrograde filling material. However, if MTA is chosen as filling material, irrigation should be completed in advance, to prevent washingthe filling material out of the cavity. For accelerating the reattachment of the flap and wound healing, the cervical area of teeth should be scaled to clear any calculus and granulation tissue (Lieblich, 2014). Following the selection of an appropriate suture material for wound closure, flap should reposition properly to its initial position and suture with least amount of tension (Sacco, Greenstein & Patel, 2016) (Figure 3). Ideally, suture removal should be performed in 3-5 days postoperatively to enhance healing. However, wounds that are closed under tension due to muscle attachments may require longer periods toattain adequate tensile strength (Parirokh, Asgary&Eghbal, 2006, Sacco, Greenstein & Patel, 2016).

Figure 3. Closure and suturing

7- Postoperative instructions:

After the procedure patients should be informed by verbally and/or in writingregarding the points to be considered during their healing process. The surgical site should not be disturbed, and the ice packs should apply from outside of the surgical area period to 15 minutes and then a 15-minute rest until bedtime. Chewing foods should be avoided until the sensation of tongue and lip returns. On the day of surgery, cool liquids and cool soft foods are recommended (Lieblich, 2014, Sacco, Greenstein & Patel, 2016,). Proper nutrition and fluid intake to prevent dehydration are important however the surgical site should not be traumatized (Lieblich, 2014). The day after the surgery, oral hygiene procedures should be started. But the teeth in the surgical area should be brushed very gently, also, surgical toothbrush can be used for this purpose. A chlorhexidine rinse, when prescribed, or warm salt-water rinse should be used twice a day to minimize inflammation and enhance soft tissue healing(Lieblich, 2014, Sacco, Greenstein & Patel, 2016). Besides, medications should be used as prescribed by the clinician. Systemic antibiotic therapy is not routinely indicated. However, mild pain is normal and to be expected following the surgery thus non-narcotic analgesics are sufficient (Evans, Bishop & Renton, 2012, Lieblich, 2014, Sacco, Greenstein & Patel, 2016). Some swelling and/or ecchymosisare also normal occurrence which will reach its maximal size in 2-3 days postoperatively (Evans, Bishop & Renton, 2012, Sacco, Greenstein & Patel, 2016). Nevertheless, patient should be instructed to immediately seek his/her practitioner in case of excessive bleeding, pain or swelling is experienced.

Retrograde Filling Materials

Various materials were used as a retrograde filling materials in the past. The material should be non-resorbable, biocompatible, and dimensionally stable over time. It should be able to induce regeneration of the PDL complex and cementogenesis in the root tip region, The handling properties and working time should be can place a root-end filling with sufficient ease (Hargreaves & Berman-Cohen, 2016). All temporary (Super EBA, IRM, Cavit, etc.)or permanent (amalgam, resin composite, glass ionomer cement, compomere, etc.) restoration material used in restorative dentistry have been used to date in apical surgery. Nowadays MTA and Biodentine retrograde filling materials have become the gold standard (Von Arx, 2011).

1. Amalgam: Amalgam has been still a frequently used retrograde filling material since it is easy to manipulate, radiopaque and nonresorbable (Bodrumlu, 2008). However, studies have shown that the amalgam weak binding capacity, inadequate regeneration and inflamation on periradiculer tissues (Balla et al, 1991). The traditional silver amalgams are highly cytotoxic due to non-reacting mercury after mixing (Tronstad& Wennberg, 1980). It is also concerned about the stability and migration of the amalgam particles. This amalgam particles have been associated with inflammation (Eley, 1982). Overall studies have shown that amalgam has poor biocompatibility (Bodrumlu, 2008).
2. Gutta-percha: Gutta percha can be highly fused and adapted to irregular walls, also it is inexpensive and ageless. Gutta percha absorbs moisture from periapical tissues due to its pleural structure when used as a retrograde filling material (Kaplan, Tanzilli and Raphael, 1982). Gutta percha has an acceptable biocompatibility with low degree of toxicity.
3. Zinc Oxide Eugenol Cement: Super-ethoxy benzoic acid (EBA) and intermediate restorative material (IRM) are reinforced zinc-oxide eugenol based cements. IRM is mostly composed of zinc oxide eugenol and less polymethacrylate. IRM provides a better sealing than the amalgam and is not affected by the root end conditioning agents (Crooks et al, 1994). IRM is biocompatible and it would be useful for retrograde filling materials. Super EBA is mostly composed of zinc oxide and less aliminium oxide and natural resins respectively. Super EBA is well tolerated when used as a retrograde filling material but it does not contribute to the regeneration of cement (Hargreaves & Berman-Cohen, 2016). The cytotoxicity of SuperEBA is similar to that of amalgam and IRM (Chong et al, 1994).
4. Glass ionomer cement: Glass ionomer cement (GIC) has been widely used in dentistry. There are two forms of light and chemically curing. Both forms of GIC have been suggested as an alternative retrograde filling material (Barkhordar, Pelzner and Stark, 1989). GIC generally is better than that with

amalgam and similar to that with IRM. It is adversly affected by moisture and blood contamination (Zetterqvist, Hall and Holmlund, 1991). Therefore, it is not recommended for use in apical surgery. Overall, studies suggest that glass ionomer cement without silver serves as a biocompatible material, but it is hardening to place in restricted area (Bodrumlu, 2008).

5. Composite resin: The biocompatibility of composite resins depends on the amount and nature of the ingredients (Geurtsen, 2000). Composite resins performs well in invitro studies when examined for sealability and leak less than amalgam, Super EBA-IRM, GICs (McDonald &Dumsha, 1990, Danin et al, 1992). Marginal adaptation varies depending on bonding agents and blood and tissue fluids in the environmen. Blood contamination reduces bonding and sealing during the process (Ambus & Munksgaard, 1993). Also, cytotoxic properties of EGDMA and TEGDMA can cause tissue damage by promoting microbial growth (Spahl, Budzikiewicz and Geurtzen, 1998). Two resin-based composite resins Geriostore (Dent-Mat, Santa Mairai, CA) and Retroplast (Retroplast Trading, Rorvig, Denmark) retrograde filling materials have been proposed (Hargreaves & Berman-Cohen, 2016). These materials are less sensitive to moisture than conventional glass-ionomer cement; however, dry environments produce stronger bonds. Geristore appears to have the potential to allow regeneration of the periradicular tissue (Cho, Kopel and White, 1995).
6. Calcium Enriched Mixture (CEM): Calcium enriched cement with different calcium compounds was introduced as an endodontic filling material in 2006. CEM cement releases calcium and phosphate ions and can form hydroxyapatite (HA) with using its own particular sources in structure. The hydroxyapatite (HA) then induces dentin bridge formation. CEM cement shows antibacterial properties and found biologically compatible in terms of cytology and genotoxicity (Memarpour et al 2016, Bahadır & Bayraktar, 2018). CEM cement has a different composition from that of mineral trioxide aggregate (MTA) but has similar clinical applications (Asgary, Eghbal and Parirokh, 2008). This cement has better antibacterial effect than MTA and can be compared to calcium hydroxide and also it has the same low cytotoxic effect as MTA in different cell lines (Asgary, Eghbal and Parirokh, 2008). When used as root end filling material in dogs teeth there was no significant difference was found between MTA (Asgary, Eghbal and Ehsani, 2010). Another a clinical study showed when CEM used as a retrograde filling material %93 periradicular lesion healed and the periodontal ligament and lamina dura were regenerated and no symptoms were observed in the teeth. This prospective study supports that CEM can be used as retrograde filling material (Kheirieh et al 2013).

7. Mineral Trioxide Aggregate (MTA): MTA was discovered by Torabinejad at the Loma Linda University, CA, USA, in 1993. MTA contains tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and other mineral oxides which prepare in the presence of moisture (Torabinejad, Hong and, Pitt Ford 1995). Mineral Trioxide aggregate (MTA) is widely used in endodontic surgery (Figure 4). MTA has been used as root-end filling material and perforation-repair material. MTA has also been used as pulp-capping material in endodontics (Pitt Ford, 2003). MTA has been extensively studied in numerous in vivo and in vitro investigations. MTA has been shown to have superior properties in terms of sealability, biocompatibility and periradicular tissue regeneration when compared to conventional retrograde filling materials. Many dye leakage and bacterial leakage studies have shown that MTA exhibited less leakage than amalgam, Super EBA and IRM (Torabinejad, Hong and, Pitt Ford 1995, Fischer, Arens and Miller, 1998). Studies in cell culture and cytotoxicity and various properties have proven to be more potent than amalgam, IRM, Super EBA, Glass ionomer, gutta percha (Osorio et al 1998, Souza et al 2006). However there is a long setting time of MTA and it is a clinical concern (Torabinejad, Hong and, Pitt Ford 1995). Compared to other root-end filling materials such as IRM, Super EBA, amalgam MTA has a longer preparation time (2 hours 45 minutes) (Torabinejad, Hong and, Pitt Ford 1995). The white MTA, a variation of the original gray MTA, has been introduced. The chemical composition of white MTA is very similar to that of the original gray MTA. Both are fine powders with a mean particle size of approximately 10 μm and the radioopacity of both materials is equivalent to 3.04 mm of aluminum (Barnes et all, 2002). They are almost identical in their overall characteristics (Hargreaves & Berman-Cohen, 2016). The tissue reaction of MTA was the presence of connective tissue one week after the operation (Economides et all, 2003). It allows the formation of cementum and bone in long time periods and causes the regeneration of the periodontal ligament (Torabinejad, Hong and, Pitt Ford 1995, Bodrumlu, 2008). Based on these reasons using of MTA as a root-end filling material has become a gold standart. Some studies evaluated microsurgical oucome using a variety of root-end filling materials, including MTA, IRM, and SuperEBA. Both MTA and Super EBA had a significantly positive influence on the outcome of treatment (Song, Shin and Kim, 2011, Song & Kim, 2012, Kim et all 2016). ProRoot MTA has showed more healed cases compared to Retroplast (Von Arx, 2011). Also, when growth factor rich plasma (PRGF) was applied on the root ends with filled MTA during periradicular surgery, patients had less pain, swelling and improved daily life activities such as mouth opening, chewing, speaking, sleeping and work (Del Fabbro et all, 2012).

Figure 4. Apical resection with MTA in the lateral tooth

8. Endosequence Root Repair Material (ERRM): ERRM is a bioceramic based material and its antimicrobial activity and biocompatibility that is similar to MTA but has greatly better handling properties (Walsh et all, 2014, Abusrewil, McLean and Scott, 2018). ERMM is available as a paste or putty form. It has been shown to be significantly greater in bone formation and cement and periodontal ligaments regeneration than ProRoot MTA (Chen et all, 2015).
9. Biodentin: New experimental calcium silicate-based bioactive restorative cement has been discovered in 2011 under the name of biodentine (Attik et all, 2014). Biodentin is a high purity calcium silicate based material. It consists of tricalcium silicate, calcium carbonate, zirconium oxide and water-based liquid calcium chloride and water reducing agent. It has a good filling capacity, high pressure resistance, short preparation time, biocompatibility, bioactivity and biomineralization properties (Laurent, Camps and About, 2012). This material can be chemically and mechanically bonded to the teeth and the composite and it is highly resistant to pressure and tendencies. Biodentin is based on calcium silicate and has mechanical properties similar to dentin and it can be used as root end filling material as MTA (Laurent, Camps and About, 2012). The reduced preparing time (12–15 min) as well as good handling and mechanical properties may make Biodentin a good alternative to MTA as a retrograde filling material (Bernabe et al, 2013, Erbaşar, Tulumbacı and Erbaşar, 2018). Good sealing ability of biodentine associated with its favorable biological properties indicate that the material can be used efficiently in clinical practice as a retrograde filling material. The fast setting time is the major advantage of biodentine in comparison to MTA (Solanki, Venkappa and Shah, 2018).

OUTCOMES OF APICAL RESECTION

Regular clinical and radiographic examination are required to determine the outcomes of apical resection. Clinical healing is dependent on the absence of particular signs and symptoms including pain, swelling, communication between marginal and apical tissues, tenderness to percussion and sinus tract. Radiologic healing can be evaluated 1-year postoperatively, however shorter period may be sufficient for small periapical defects. Periapical radiographs, made with an intraoral paralleling technique, allow for more accurate comparison between preoperative and postoperative views(Evans, Bishop & Renton, 2012, von Arx, 2010). The radiologic healings, according to the histopathological studies that examined periapical tissues around the teeth which extracted after endodontic surgery, are classed as complete healing, incomplete healing *(scar tissue formation)*, uncertain *(partial resolution of periapical defect)* and unsuccessful *(no resolution or an increase resolution in periapical defect)* (Molven, Halse&Grung, 1987, Rud, Andreasen &Möller Jensen, 1972, von Arx, 2010).

In the literature, the reported success rates of apical resection procedures are conflicting ranging from 37% to 96% (Evans, Bishop & Renton, 2012, Kim & et al., 2016, Tortorici& et al., 2014). As a matter of fact,with the introduction of microsurgicaltechniquesand the improvements in retrograde filling materials have increasedsuccess rates of the endodontic surgery procedures.In the study of Tortorici et al, clinical success ratesat 1 year postoperatively were reported as 67% for traditional apicoectomy, 90% for microsurgical apicoectomy using burns for osteotomy and 94% for microsurgical apicoectomy using piezo-osteotomy, respectively (Tortorici& et al., 2014). Similarly, a meta-analysis demonstrated that the probability of success for microsurgical techniques was 1.58 times greater than the probability of success for traditional root-end surgery techniques (Setzer & et al., 2010).

Based on the retrograde filling material, Tortorici et al reportedsuccess rates of 90.8% for silveramalgamand 96% for MTA at 5 years postoperative (Tortorici& et al., 2014). Accordance with these results, the study of Kim et al in which all surgical procedures were performed using a surgical microscope, reported 91.6% of success rate for MTA and 89.9%of success rate forSuperEBAat the 4-year follow-up (Kim & et al., 2016).Furthermore, a recent meta-analysis demonstrated that the probability for success for endodontic microsurgeryusinghigh-magnification ultrasonic instruments for retrograde cavity preparation and SuperEBA, IRM, MTA, or other calcium silicate cements for retrograde filling materials, is significantly greater than the probability for success for resin-based endodontic surgery using high-magnification for preparation of a shallow and concave retrograde cavityand bonded resin-based for retrograde filling material (Kohli & et al., 2018).

CONCLUSION

Improved microsurgical instruments, ultrasonic tips, and current biocompatible retrograde filling materials have improved the evaluation of healing of periradicular tissues. It has been an alternative method for tooth extraction with appropriate case selection, increased skill and advanced current materials.

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Chapter 9

ANALYSIS OF DENTAL FINDINGS FOR AGE ESTIMATION PRACTICES IN PRENATAL PERIOD

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INTRODUCTION

Age estimation of individuals is one of the basic procedures followed in forensic cases. Different techniques are applied for each age group in the age estimation analysis of identification studies. The age estimation contributes to the three main subjects of the forensic aspect: evaluation of skeletal maturity, identification of secondary sex characteristics and observation of dental development (Black & al., 2010).

With forensic odontological approaches, age estimation is possible in different age groups. There are more methods for adults and the reliability of each method is different (Singh & Singal, 2017). Age estimation practices for prenatal period are limited due to lack of samples and ethical conditions. In addition, indicators that can be followed for age estimation in fetuses are more complicated than other age groups.

The purpose of dental age estimation in fetuses is to evaluate the preterm birth and abortion cases (Prathap, 2017). Fetal dental age estimation is of great importance in determining live births. Dental development, formation of ossification centers and development of long bones are basically evaluated for age estimation in fetuses (Ubelaker, 1987). For these studies, techniques involving long bone measurements more varied and special studies are being developed for different populations (Carneiro & al., 2013). Dental development also shows variations between populations as in the development of many skeletal components.

Teeth are less affected by factors such as nutrition and hormonal changes than the bones. Therefore, assessing dental maturity is a reliable indicator of age estimation (Lewis & Garn, 1960; Demirjian & al., 1985; Brickley & McKinley, 2004; Bérgamo & al., 2016). There is also a close relationship between bone and tooth growth (Donni & al., 2018). Dental age is an indicator that determines the biological age by analyzing the growth and development of the teeth. This indi-

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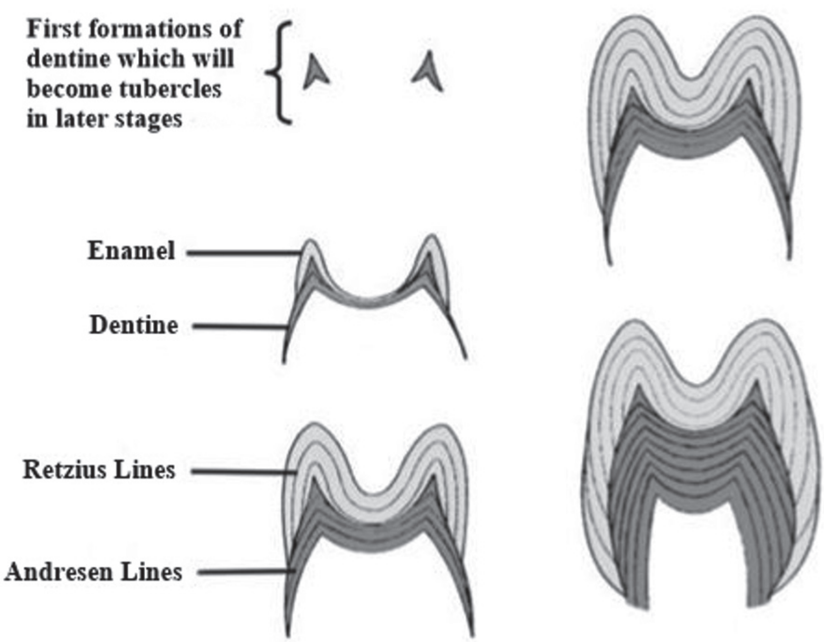
cator gives a more accurate age range than the chronological age and is evaluated with calcification or tooth eruption (Kania & al., 2010).

EARLY STAGES OF DENTAL DEVELOPMENT

Teeth are frequently evaluated in age estimation. Because teeth, begin to develop in the early stages of the embryonic period and are resistant components that provide data that can be reached even after longtime from death (Bérgamo & al., 2016).

Dental formation is mostly observed for dental age estimation in prenatal period. The term of ‘’tooth formation’’ used in age estimation is often used for mineralization of hard tooth tissues. This term does not include the non-mineralized early stages of dental germs (Nayyar & al., 2016).

The stages of enamel and dentin development can give clues to prenatal age estimation. Gradually growing Retzius lines are caused by changes in the rhythmic mineralization of the enamel (Schema 1). This form of mineralization can be affected by many factors such as metabolic disorders. Therefore, the completion time of these lines may be delayed (Shamim & al., 2006). By examining the development of Retzius lines, age can be estimated from the 5th month of the prenatal period to the 7th month of the postnatal period (Pretty, 2003).



Schema 1. Development of Enamel and Dentin

Neonatal lines are also important for forensic cases and epidemiological studies as they are an indicator of live births. (Kotecha, 2016). These lines are seen in the enamel and dentin of the deciduous teeth and first permanent molar. For this reason, neonatal lines can be used to evaluate prenatal and postnatal enamel formation (Shamim & al., 2006). There are also Von Ebner lines and outer lines that develop gradually in dentin. These lines are used to estimate the age of death for prenatal or neonatal periods (Pretty, 2003).

Deciduous teeth begin to develop in the 6th-8th weeks and permanent teeth in the 20th week of pregnancy (Nayyar & al., 2016). Upper central incisors are the most easily defined teeth because of their early development (Aka & al., 2015b). Prenatal mineralization begins with the first molar, lateral incisor, canine and second molar after the central incisor in primary teeth (Logan, & Kronfeld, 1933; Scheuer & Black, 2004).

THE MOST COMMON TECHNIQUES

The most reliable dental analysis is carried out through oral autopsies in forensic researches (Aka & Canturk, 2014). Oral autopsy practices differ according to age groups due to rigor mortis. Fetus and infants' muscle strengths are low than adults. So, their autopsy procedures are easier (Aka & Canturk, 2014). Oral autopsies can be used to isolate teeth from maxilla and mandible (Image 1).

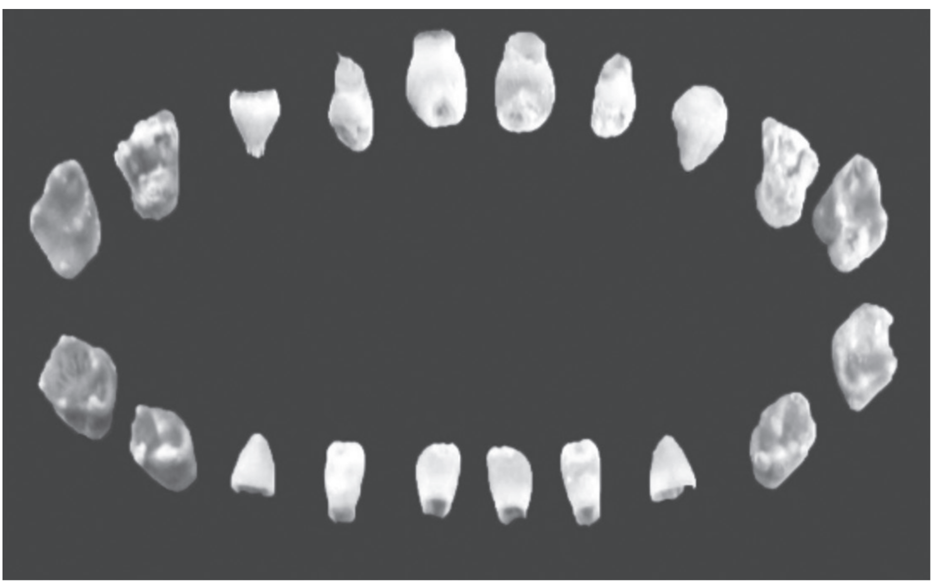


Image 1. Samples of Primary Teeth from an Autopsy Case (Aka & al., 2015a)

Histological, radiological and morphological techniques were generally used in prenatal age estimation studies until today. Each fetal dental age estimation method has advantages and disadvantages. In addition, the age range in which each technique can be used varies.

Periapical, bitewing and panoramic radiographs that also evaluated clinically are frequently used in forensic dental diagnoses (Queiroz & al., 2016). It is aimed to follow the development of teeth with the radiographic examinations from the first stages of mineralization to root formation and closure of root apex (Uzuner & al., 2018). Age estimates made through dental development for prenatal and neonatal periods are based on observation of calcification levels in primary teeth by radiological methods (Nayyar & et al., 2016).

Mineralization periods that seen in radiographs are usually shorter than the duration of full crown and root formation (Scheuer & Black, 2004). Incisor teeth can be radiographically observed from 16th week of intrauterine life (Nayyar & et al., 2016).

Histological methods aim to provide detailed observation of dental development stages by microscopic analysis (Prathap, 2017). These methods are used to evaluate the development of teeth in the pre-mineralization period. The application of histological techniques is relatively more difficult than other methods. These techniques are applied by dividing fetal teeth into sequential sections, dissection, staining with alizarin and include histological analyses carried out by radiological researches (Scheuer & Black, 2004).

Examination of the use of appliances such as SEM cause damage to the tooth sample is a disadvantage (Aka & Canturk, 2014). Histological examinations provide age estimation in the early stages of the prenatal period and this is an important advantage. Because in the early stages, both the enamel and the dentin are low radiopaque (Hess & al., 1932).

There are different opinions about the time of the early mineralization phases to be visualized by histological and radiological equipments. For example, according to Hess et al. (1932), mineralization can be histologically visualized up to 6 months before radiographs. Shamim et al. (2006) with Donni et al. (2018) reported that some of the histological methods provided recognition of early mineralization stages. According to these researchers, teeth are not seen in radiographs in these stages up to 12 weeks. Enamel and dentin up to 6 months of the prenatal period are not radiopaque to appear on radiographs. In this period, it is recommended to use the technique based on the staining of the teeth with alizarin by using gravimetric method (Uzuner & al., 2018).

EXAMPLES OF DENTAL AGE ESTIMATION STUDIES

Stack (1964) defined a gravimetric technique by measuring the dry weight of mineralized tooth tubercles -namely dentin weight- and determined the approximate age ranges. The weight of dentin was 60 grams in the 6th month of fetal life and 0.5 grams in newborns. Six months after birth, dentin weight increased by 1.8 grams.

Kraus and Jordan (1965) studied the early mineralization of deciduous teeth and permanent first molar with data from 95 fetuses. The developmental stages of these teeth are defined in 10 stages. Given Roman numerals from 1 to 10 for this scale. Phase 9 three, Phase 10 consists of five stages.

In the study of Deutsch & Pe'er (1982), enamel growth of the maxillary and mandibular central and lateral incisors of the fetuses between the ages of 5-9 months were observed. Subsequent researches, evaluated the relationship between enamel development and fetal age , led to observation of enamel ratio and development for each tooth.

Lalys et al. (2011) evaluated 49 fetuses and 40 mandibles. In this study, it was aimed to determine the relationship between primary teeth germs and age estimation. The researchers reported that limit of the ''amenorrhea'' 'is 22 weeks for forensic cases in France. The most accurate age estimate obtained was 4.6 weeks from ''amenorrhea''. However, researchers need more reliable results.

There are studies evaluating the relationship between different teeth and body measurements with age. Dagalp & al. (2014), evaluated the head circumference and upper central tooth measurements including prenatal fetuses. As a result, the growth of the measured variables has been close to each other. Eight age estimation formulas which including measurements were created such as tooth and crown height.

Aka & Canturk (2014) presented the ''Aka – Canturk Oral Autopsy Method'' in order to isolate dental germs, identify developmental stages and describe the oral autopsy processes completed in this way. This method has been an important reference for the estimation of the age of the fetus and infants. Researchers have indicated that such oral autopsies can be used in abortions and deliberate abortions, mass disasters and abandonment cases.

It is a easily applied scientific technique that is used to evaluate the age-related relationship with dental development and to measure the length of the developing teeth directly (Liversidge & al., 1993). Aka & et al. (2015b) with direct or indirect measurements of teeth through CT images, it is aimed to estimate the age of fetuses and infants (Image 2). Age estimation formulas were calculated using dental measurements. It was revealed that observing the development of the upper central central teeth until the completion phase will make a significant contribution to forensic dental identification studies.

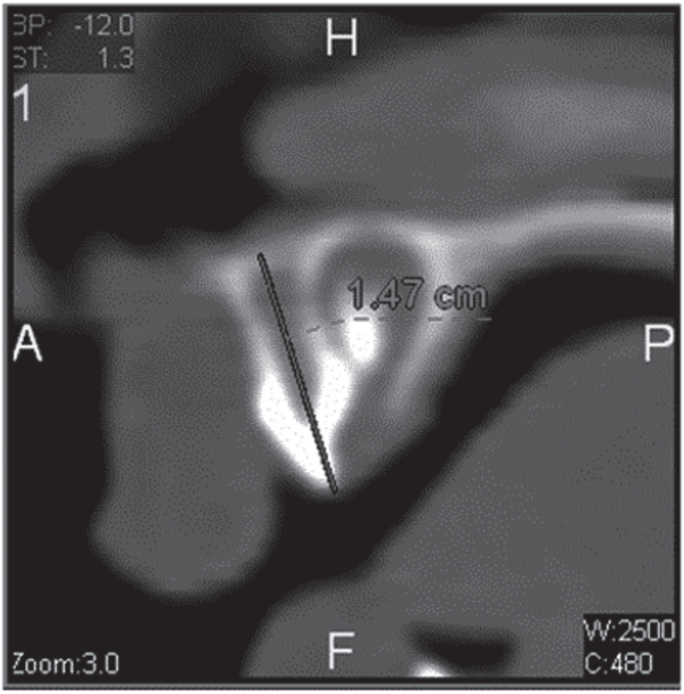
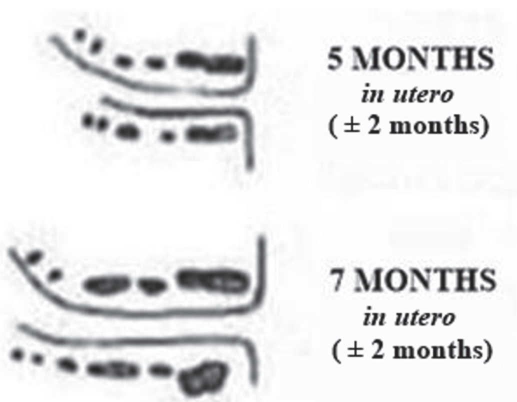


Image 2. Indirect Tooth Length Measurement in Sagittal Plan from CT Image (Aka & al., 2015b)

Apart from these studies, there are also dental development scales created for use in different contexts for age estimation. In Scheme 1 and Scheme 2, examples of sections of these scales that include fetal life are given.



Scheme 1. A Section from Native American Sample (Ubelaker, 1978)

Scheme 2. Fetal Dental Development Scale (AlQahtani & al., 2010)

CONCLUSION

The teeth are less affected by genetic and environmental factors than other skeletal components. Therefore, the teeth are frequently evaluated as a reliable indicator in age estimation studies. It is an advantage that the teeth can be used in the early stages of the prenatal period in the estimation of age.

Bone development is also considered for prenatal age estimation. Although it is possible to reach the bone development findings clinically in gynecological examinations, the situation becomes difficult for the buried skeletal remains. These bone tissue, which is not yet dense in mineralization, can be damaged more easily than baby, child and adult bones. For forensic contexts, teeth can be accessed with less damage compared to the bones.

The use of combinations or appropriate statistical methods for different age estimation methods from a statistical and methodological perspective ensures reliable results (Nayyar & al., 2016). According to the data obtained from the cases, the available indicators can be evaluated together and different confirmatory findings can be used in age estimation. In addition, it is possible to associate dental age with different proportions of body parts. In metric studies, dental measurements are recommended to be repeated for reliable results.

In the first studies on the development of the teeth in the prenatal period, the sample size and age range and the methods applied are not sufficiently clear. In addition, it makes it difficult to carry out new studies due to the rarity of access to fetal tissues (Scheuer & Black, 2004). In this case, the different ethical procedures of the countries have a great effect. However, new techniques need to be developed and special dental development scales are needed for populations. The data on the prenatal period are limited in the dental development scales. The more extensive these scales will contribute to forensic cases, as well as growth–development studies, clinical practices, anthropological and archaeological researches.

Current studies contribute to the identification of cases and are guiding for subsequent researches. Nevertheless, more research is needed in collaboration with interdisciplinary data. Fundamentally, should be consulted to related fields such as forensic odontology, forensic medicine, forensic anthropology, gynecology and anatomy in these studies.

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Chapter 10

THE SHORTENED DENTAL ARCH CONCEPT

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Mustafa Hayati ATALA[2]

Caries and periodontal diseases can cause loss of posterior teeth which is most effective chewing units of the stomatognathic system. The rehabilitation of missing teeth is one of the main goals of actual dental research. But, it is questioned that all missing posterior teeth should be replaced to achieve healthy chewing function, oral comfort and maintain the dynamics of the stomatognathic system. Nowadays, various prosthetic interventions can be used to replace missing posterior teeth include removable partial dentures, fixed partial dentures and implant supported dentures. However, financial constraints, systemic diseases and time-consuming prosedures are most common reasons for patients who do not demand dental treatments.

Clinicans should consider the remaining teeth, the systemic condition of patients, the temporomandibular joint and the patient's demands while planning and choosing the dental treatment option. As an alternative choice, the presence of anterior teeth and few occlusal contacts in the presence of posterior teeth can be considered as a specific dentition, namely shortened dental arch concept (SDA). In 1981, 'Shortened dental arch'concept is presented by Kayser who is a prosthodontist (Kayser,1981a). According to Kayser and his colleagues, shortened dental arch concept can be described as the type of dentition with a minimum of 20 occlusal units and this is sub-optimal but can be acceptable for patient's healthy stomatognathic function. One occlusal units can be defined as one pair of occluding molars or premolars. It was stated that four occluding units could be sufficient to meet the properties of a healthy occlusion. Similarly, in 1992, the World Health Organization (WHO) stated that the dentition consisting of 20 well-placed teeth could successfully meet functional and aesthetic expectations. (Alam ve ark.,2014) Although shortened dental arch concept can be considered as a simplified treatment approach (Gupta ve ark.,2016), the concept is controversial

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due to it has a different perspective from that which is targeted in conventional dentistry. It was claimed that the shortened dental arch concept has undesired effects such as temporomandibular disorders, tooth migration, poor masticatory performance and impaired quality of life. (Solow, 2010, Gupta ve ark.,2016) The studies which aim to identify effects of shortened dental arch concept on the physiology of stomatognathic system, occlusal stability, oral health-related quality of life and clinicans' attitudes have been done.

SHORTENED DENTAL ARCH CONCEPT AND CHEWING FUNCTION

Chewing, is the beginning of digestion process and important to take adequate vitamin and nutrient. Chewing is one of the basic functions of the stomatognatic system, and it is carried out by means of occluding contact of the teeth as a result of rhytmic jaw movements. Although, the number of teeth present in mouth is important in chewing function, it is stated that the position of teeth and occluding teeth pairs are more effective (Ikebe ve ark.,2011a, Ikebe ve ark.,2012b,Fueki ve ark., 2010,Sierpinska ve ark.,2006, Oosterhaven ve ark.,1988,Van Der Bilt ve ark.1993).

Occlusal surface of teeth is crucial for the capacity to grind food. Thus, occlusal surfaces are proportional with chewing capacity [Ikebe ve ark.,2011a]. It is stated that the loss of posterior teeth may reduce the ability to shredding food and it can decrease chewing efficiency by approximately 50% (Kreulen ve ark.,2012). Loss of molar teeth which have wide occlusal surface should effect chewing habits of person. Decreasing chewing ability can be tried to be compensated by increasing the chewing cycles. Individiuals with SDA perform 70% more chewing cycles (Kreulen ve ark.,2012). Reduced dentition can change food preference too. It has been stated that subjects with shortened dental arch preference soft foods that are easier to chew instead of fiber foods such as vegetables. (Gunne 1985) This alteration in nutritional habits may affect the digestive system and vitamin intake and may adversely affect the general health status of the patient. (Krall ve ark.,1998, Yoshida ve ark.,2011)

In a study, the relationship between shortened dental arch and chewing complaints of subjects are evaluated. Prevelance of chewing complaint is defined as %3-5 for subjects with absence of second molars, but this prevelance can be seen as %95-98 when presence of 0-2 pair premolar teeth (Sarita ve ark.,2003). Kayser stated that chewing performance should be impaired significantly when the number of occluding units less than 4 symetrical or 6 asymetrical position. (Kayser,1981a, Sierpinska ve ark.,2006, Oosterhaven ve ark.,1988) So, it can be concluded that presence of 20 well-positioned anterior and premolar teeth can support masticatory function and nutrition properly (Witter ve ark.,1990a, Khan ve ark.,2014a).

SHORTENED DENTAL ARCH AND TEMPOROMANDIBULAR DISORDERS

Reduced chewing performance due to teeth losing can cause trauma to temporomandibular joint and histologic changes, disk deplacement and pathological changes etc. can be seen (Tallents ve ark.,2002). But, it was not proved that an exact relationship between the SDA and temporomandibular joint dysfunction. Previous studies stated that temporomandibular joint should adapt to changes of dentition and shortened dental arch concept would not impair stomatognatic system and temporomandibular joint (Witter ve ark.,1988b, Witter ve ark., 1994c). The neuromuscular feature of the temporomandibular joint should probably protect the joint against excessive forces caused by tooth loss (Hattori ve ark.,2003). It was stated that there were no symptoms of temporomandibular joint dysfunctions in subjects with shortened dental arch (Manola ve ark., 2017).

Rehabilitation of lost teeth can prevent occlusal problems and temporomandibular complaints. But, it is claimed that shortened dental arch should not be a reason for adverse conditions such as disk displacement and temporomandibular joint diseases (Alam ve ark.,2014, Solow.,2010). Also, when evaluating the relationship between oral health-related quality of life and temporomandibular disorders, it was reported that absence of molar teeth did not make a significant difference (Owen.,2004).

Comparing the studies which evaluating the symptoms of temporomandibular joint disorders and teeth loss is difficult because these studies are related with number of missing teeth (Witter ve ark., 2001d, Ciancaglini ve ark., 1999) or the localization and the position of presence teeth. Temporomandibular complaints can be caused by multiple factors. So, In the case where other factors are kept the same, the relationship between TME complaints and shortened dental arch concept can be better understood.

SHORTENED DENTAL ARCH AND OCCLUSAL STABILITY

After teeth loss, remaining teeth try to adapt new occlusal conditions and tooth migration towards the spaces is occured. The teeth which are not in the ideal position and occlusion with the opposite teeth may be exposed to higher occlusal forces and so, impaired occlusal stability can disrupt supportive feauture of periodontal tissues (Witter ve ark., 1991e, Sarita ve ark.,2003). It was searched that how shortened dental arch concept will affect occlusal stability [Witter ve ark., 2001d, Sarita ve ark.,2003]. Occluding of remaining tooth pairs can prevent migration. Studies described that the shortened dental arch concept could not cause pathological condition. It is confirmed that changes in the presence teeth and support tissues in the mouth remain stable over time, and this can be described as physiological adaptation to the new condition, not pathological [Witter ve ark., 2001d, Witter ve ark.,1994c].

SHORTENED DENTAL ARCH AND PROSTHETIC TREATMENT

Removable partial denture can be favourable in cases of lost posterior teeth. It should be planned properly to avoid adverse effects on the supporting tissues. Unilateral or bilateral free ended removable partial dentures can meet the aesthetic demands but, free end removable partial denture does not improve patient's oral comfort or provide increased chewing function (Aras ve ark., 2009, Wolfart ve ark.,2012a). It was stated that as long as the patient could chewing adequately, it was not necessary to restore all lost teeth with prosthetic treatment. (Abuzar ve ark.,2015) The designing of removable partial denture should be done considering the remaining teeth, bone tissues and the stomatognathic system. If not ideally planned, removable partial dentures may cause caries and may have negative effects on tissue support. (Thomason ve ark.,2007, Jepson ve ark.,2001) In addition, it is stated that chewing cerebral activity with removable partial dentures is less than that of natural teeth because removable partial dentures cover soft tissues which can change physiological stimulus (Shoi ve ark., 2014). So, when planning removable partial denture in cases which posterior teeth loss, biological advantage should be carefully evaluated (Khan ve ark.,2014a, Khan ve ark.,2012b). Also, subjects with the shortened dental arch can maintain health of soft and hard tissues for over 27 years. So, removable partial denture may be affirmative in cases of less than 20 occluding teeth.

Implant retained dentures is presented as a popular alternative to removable partial dentures. Dental implants provide better posterior support and esthetic advantage than removable partial dentures. But, implant treatment require surgical procedures and also it is expensive and time-consuming. Surgical operation and dental treatments may be exhausting and sometimes systemic diseases of individuals are an obstacle to these treatments. Clinicans should consider patient related factors deciding prosthetic intervention.

According to shortened dental arch concept, 20 well occluding teeth should be adequate for masticatory function even if increased chewing cycles. The concept has been accepted by the clinicans as a simplified approach and so, it can be taken into account as a convenient rehabilitation for elderly communities and patients in developing countries.

SHORTENED DENTAL ARCH AND ORAL HEALTH-RELATED QUALITY OF LIFE

The impact of dental treatment on quality of life is an recognised topic and increasingly evaluated with studies. Similarly, some studies have tried to evaluate quality of life related to oral health for individuals with shortened dental arch. Systemic reviews have concluded that there is a proportional relationship between tooth loss and impairment of OHRQoL (Gerritsen ve ark.,2010, Tan ve ark., 2016). Quality of life related to oral health can be related with symmetrical or asymmetrical occlusal contacts of the posterior teeth, number of occluding units (Kayser 1989b, Armellini ve ark.,2004). Although occluding premolar teeth can improve patient satisfaciton, it was stated that molar teeth deficiency did not change oral health related to quality of life significantly (Wolfart ve ark., 2005b, Gerritsen ve ark.,2010).

In fact, nine or more number of anterior and posterior teeth with occlusal contacts should be accepted as a limit. (Gerritsen ve ark.,2010,Fueki ve ark.,2011). So, shortened dental arch concept would not impair badly quality of life if the number of occluding teeth is more than nine. In a previous randomized controlled clinic study, after 12 months follow-up, there is no significant difference between quality of life of participants with shortened dental arch and removable partial dentures (McKenna ve ark., 2015). The concept is very convenient for situations in the number of remaining teeth should not alter quality of life (Kiola ve ark.,2007, Tan ve ark.,2015).

SHORTENED DENTAL ARCH AND CLINICAL ATTITUDES

Age is the one main factors which are related with tooth loss (Cohen ve ark, 1989). Since 1960, average lifetime of population has increased more than in previous years. (Murdock ve ark., 1988) So, requirement of dental treatments due to missing teeth will increase. Probably, requirement of dental treatments would increase. Clinicans' assessment for elderly patients should be important. Because, systemic conditions and inadequate oral hygen which can be seen mostly elderly population should complicate dental treatment. Therefore, clinicans' knowledge and awarness about the shortened dental arch concept is important to present proper option to patients.

There are studies which is about dentists' attitudes related with shortened dental arch have been published. Although most dentists are aware of shortened dental arch can be supply adequately chewing function, oral comfort and esthetic demands, they prefer to construct prosthesis for missing posterior teeth.(Allen ve ark.,1996, Nassani ve ark.,2010) Around the world, the studies related with awareness of dentist about shortened dental arch are published.

In the end of 1990s, according to the survey among the European dentists is widely accepted the concept. (Allen ve ark.,1996) In a study conducted in Nigeria in 2009, 36.1% of dentists reported that the concept was a good option for developing countries like Nigeria. (Arigbede ve ark., 2009) In a study in India, it was reported that prosthodontists' attitudes is positive in the concept. (Kumar ve ark.,2012) In Malaysia, dentists know the concept of a shortened dental arch, but it has been shown that the application is not performed to a large extent in the clinic.(Kasim ve ark.,2018) In India , the knowledge, awareness and practice of the shortened dental arch concept of dentists were evaluated. According to the results of this study, it is reported that there is an accurate ratio between the experience of the dentist and his awareness of the concept (Gupta ve ark.,2016).

The studies between 1980 and 2014 about the shortened dental arch concept was evaluated in 9-year periods. While the number of studies supporting the concept remained the same, the number of studies that did not support the concept increased.(Manola ve ark., 2017)

Despite the awareness of the dentists and the positive attitude, the concept is less applied over the years. The reason for this is the advances in the treatment options and materials of dentistry today. However, the shortened dental arch concept can be considered as a good alternative to patients, because it is less time-consuming, less costly and less complicated.

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