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Management of Dental Luxation and Avulsion Injuries in the Permanent teeth

A Project Submitted to
The College of Dentistry, University of Baghdad, Department of Orthodontics in Partial Fulfillment for the Bachelor Degree in Dentistry

By
Safa Muthanna Abd- alkareem

Supervised by:
Dr.Shahbaa Abd Al-Ghafor Mohammed
Assist. Prof. Dr.

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Certification of the Supervisor

I certify that this project entitled "Management of Dental Luxation and Avulsion injuries in the permanent teeth" by the fifth year student Safa Muthanna Abd-alkareem under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name: Dr.Shahbaa Abd Al-Ghafor Mohammed

Date:

Dedication

To My wonderful and greatest

Father and mother, who

provided me with their

… Love and support

To my lovely brothers and sister

(Mustafa, Ali, and Rasha)

And to All my family

Acknowledgment

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	List of abbreviations
RPMI	**Roswell Park Memorial Institute tissue culture medium**
IADT	**International Association of Dental Traumatology**
CBCT	**cone-beam computed tomography**
PDL	**Periodontal ligament**
NITI	**Nickel titanium**
HBSS	**Hanks balanced salt solution**

Introduction

Dental trauma mostly occurs in the age group of 7-19 years and is most prevalent in boys. Most commonly involved teeth during dental trauma accidents are the maxillary incisors. Commonly associated risk factors during trauma for class 2 patients division 1 malocclusion are increased overjet and incompetent lip coverage. If there is an increase up to 0–6 mm, then it increases the threat of dental injury due to trauma which makes incomplete or partial lip closure resulting in unsupported maxillary incisors which is also said to be one of the majority factors in escalating the occurrence of traumatic dental injuries. According to the Children's Dental Health Survey 2003, it is being reported that from 5% at age 8 to 11% by age 12 have undergone accidental damage to their permanent incisors. Data shows that many of them are remaining untreated. There is also evidences that 10.8% of orthodontic patients have a history of dental trauma**(Karishma *et al.*, 2020).**

The factors establishing the type of lesion are the force and direction of the impact of the injury. Dent alveolar injuries involve fractured, displaced, or lost teeth.Most of the time, these are complex injuries involving different types of tissues that require careful examination, accurate diagnosis and treatment planning. Over and above, this must happen promptly, all within a matter of minutes**(krisha *et al.*, 2021)** .

The management of traumatic injuries has not traditionally been an area of practice for the orthodontist; consequently, he or she is often not well equipped to handle the injury. The frequency of orthodontic appointments, however, results in the orthodontist developing a close relationship with the patient and family, and since the injury often damages the orthodontic appliance, the orthodontist is often contacted first **(Graber, 2017).**

Aim of the study.

To short review about management of dental luxation and avulsion injuries, which by their nature (malposition) and treatment requirements (orthodontic splinting or alignment) can fall within the purview of the practicing orthodontist.

Chapter one
Review of Literatures

1.1Tissue response to trauma

The proper management of luxation and avulsion injuries requires an understanding of the immediate and short-term response to the involved tissues: the periodontal ligament (PDL), pulp, and alveolar bone.**(Graber, 2017)**

1.1.1 The Periodontal ligament (root resorption) response

• Trauma to the tooth often results in damage to the PDL.

• The amount of damage depends on the severity and type of injury and may include tearing, severing, or compression of the ligament.

• Root resorption is the common response to PDL injury; generally, the three types are surface, inflammatory, and replacement resorption**(Andreasen and Hjorting, 1966).**

Surface resorption is the least invasive, although it may involve both cementum and dentin; it is self-limiting and shows spontaneous repair. Surface resorption radiographically appears as small excavations on the root surface adjacent to a PDL space of normal width. Inflammatory resorption results from infected necrotic pulp tissue, which then affects the traumatized PDL **(Andreasen, 1981)**This type can quickly destroy root structure, and without endodontic treatment, the loss of the tooth usually occurs within 2 to 10 months. Characterized by bowl-shaped excavations in the root surface. Replacement resorption usually follows severe injuries in which the PDL has been removed or severely damaged **(Andreasen and Hjorting, 1966).**

Ankylosis accompanies replacement resorption, and the slow process of continuous replacement of root structure by bone results in the eventual loss of

the tooth over a period of years. Progressive root resorption (inflammatory and replacement resorption) occurs most frequently after intrusion or avulsion injuries

Radiographically, the root surface is highly irregular, with the normal lamina dura absent and the tooth structure obviously diminishing.Removing the pulp tissue and placing calcium hydroxide in the canal is the treatment for root resorption **(Graber, 2017).**

1.1.2 PULPAL RESPONSE

1.1.2.1 Pulp Necrosis

Pulp response and survival depend on the type (severity) of the injury and the stage of root end development. The diameter of the apical foramen is the most important factor in pulp survival **(Graber, 2017).**

Teeth with open apices show a higher survival rate, especially with the less severe injuries such as concussion, luxation, lateral displacement, and extrusion.

Pulps of intruded and avulsed teeth with closed root apices rarely survive.

To prevent the necrotic pulp from potentiating the process of progressive root resorption, endodontic treatment with calcium hydroxide is recommended within a few weeks after the injury **(Andreasen, 1985; Spalding *et al.*,1985).**

Later, when no signs of root resorption are evident, calcium hydroxide is replaced with traditional endodontic therapy.

In the case of a non vital pulp with incomplete root formation, root-end induction procedures must be accomplished first **(Frank, 1966).**

1.1.2.2 Pulp Canal Obliteration

In a significant number of cases (15% to 22%), the pulp may undergo a slow process of obliteration.

Calcification usually starts coronary and may completely obliterate the pulp chamber. Pulp canal obliteration more frequently occurs in teeth with open apices that have experienced a severe luxation injury and seems to be a sequel to re vascularization and/or innervation of a damaged pulp. minority of these teeth will develop future pupal necrosis, endodontic treatment is not usually recommended **(Jacobsen and Kerekes, 1977).**

However, because of the difficulty of performing endodontic treatment after pupal obliteration, some endodontists recommend prophylactic treatment, once root formation is complete and pupal obliteration is beginning to be apparent. **(Crona-Larsson *et al.*,1991).**

1.1.3 ALVEOLAR FRACTURE

Luxation injuries are often associated with a fracture of alveolar bone. Fracture lines may be located at any level from the marginal bone to the root apex. In addition to regular periapical views, radiographs with varying horizontal angles, an occlusal view and/ or a panoramic radiograph, or focused cone-beam computed tomography (CBCT) can be helpful in determining the course and position of the fracture lines **(Diangelis *et al*., 2012).**

Clinical examination may reveal granulation tissue in the gingival crevice or the secretion of pus from the pocket. Loss of marginal bone frequently occurs with intrusion injuries **(Graber, 2017).**

2.1 Management of trauma and immediate sequelae

With an understanding of the common tissue response that follows a traumatic injury, the practitioner can better man- age the different injuries that may occur. The management of traumatic injuries to be discussed is based on Guidelines pub lished by the International Association of Dental Traumatology

(IADT). Luxation injuries are classified as concussion, sub- luxation, extrusive luxation, lateral luxation, and intrusive luxation. Avulsion is classified separately **(Graber, 2017).**

2.1.1 Avulsion

The avulsion injury is seen in 0.5% to 3% of all dental injuries and is characterized by a complete displacement of the tooth out of the alveolar socket. This injury is accompanied by comminution or fracture of the alveolar socket **(Graber, 2017).**

2.1.1.1 Treatment Guideline of avulsed permanent teeth

Critical factors to the long-term survival of these teeth are the physiologic status of the PDL cells, extraoral period, stage of root development, storage medium, and method of stabilization. Approximately 90% of the teeth reimplanted within 30 minutes showed no root resorption. The best storage medium is in the patient's mouth; hence, parents or guardians should be instructed over the telephone how to reposition the tooth back into the socket **(Graber, 2017)**.

Immediate replantation is the best treatment at the place of accident.

•If a tooth is avulsed, make sure it is a permanent tooth (primary teeth should not be replanted) **(Ashraf *et al.*, 2020)**

• Keep the patient calm. **(Ashraf *et al.*, 2020)**

• Find the tooth and pick it up by the crown (the white part). Avoid touching the root. **(Ashraf *et al.*, 2020)**

• If the tooth is dirty, wash it briefly (max 10 seconds) under cold running water and reposition it. Once the tooth is back in place, bite on a handkerchief to hold it in position. **(Ashraf *et al.*, 2020).**

•If the tooth cannot be repositioned, then it can be placed in the vestibule or under the patient's tongue. If this is not possible (e.g. an unconscious patient),

the tooth should be transported in a proper storage medium. Hanks balanced salt solution (HBSS), a tissue culture medium, is commercially available to dentists and has been shown to improve the viability of remaining PDL cells. Milk may be as good a storage medium as any of the commercially prepared solutions for up to 6 hours. The tooth should not be stored in water**. (Graber, 2017)**.

• seek emergency dental treatment immediately. **(Ashraf *et al.*, 2020)**

The Importance of reimplantation is

1) The replanted tooth serves as a space maintainer and often guides the adjacent teeth into their proper position in the arch, a action that is important during the transitional dentition period.

2) The replantation procedure also has psychological value. It gives the unfortunate child and parents hope for success; even though they are told of the possibility of eventual loss of the tooth, the early result often appears favorable and softens the emotional blow of the accident . **(Angus and Richard, 2013)**

There are two types of management of avulsed teeth:

A. Treatment of avulsed teeth with closed apex (Graber, 2017).

A tooth with a closed apex that arrives at the office having been replanted after a short time has an excellent chance of survival. The orthodontist should clinically and radiographically verify the position of the tooth. After cleaning the area with water spray, saline, or chlorhexidine, a flexible splint is applied and worn for up to 2 weeks. Endodontic treatment should begin 7 to 10 days after replantation but before removing the splint.

The tooth that arrives at the office in a physiologic storage medium or after a dry time of less than 60 minutes should be replanted by the orthodontist. The root surface and apical foramen are cleaned with saline, and the tooth is soaked in saline while preparing to replant. A local anesthesia is administered, and the socket is irrigated with saline. The alveolar socket is examined, and any

fractured or displaced socket wall is reposition. The tooth is slowly replanted with slight digital pressure, and the normal position of the tooth is clinically and radio- graphically verified. A flexible splint is applied, and endodontic treatment should begin 7 to 10 days after the replantation but before removing the splint.

If the closed apex tooth has dry time longer than 60 minutes, then the PDL cells are necrotic; hence, the eventual outcome is ankylosis and root resorption and the eventual loss of the tooth. Before replantation, the orthodontist should carefully remove attached nonviable soft tissue with gauze. Endodontic treatment can be performed before or after replantation. Replantation is performed as previously described, and a flexible splint is applied and worn for 4 weeks. To slow down osseous replacement of the tooth, some have suggested treating the root surface with 2% sodium fluoride for 20 minutes before replantation**.**

B. Treatment of avulsed teeth with open apex (Graber, 2017).

Teeth immediately replanted with open apices are treated as previously described but are not endodontically treated since the pulp may revascularize. If that does not occur, then endodontic treatment will be indicated.

Teeth with open apices in a proper storage medium or with a dry time less than 60 minutes should be replanted as previously described. Before replantation, the topical application of antibiotics minocycline or doxycycline) has been shown to enhance the chances for revascularization, 1 mg per 20 mL of saline for a 5-minute soak. The pulp space may revascularize; however, infection-related root resorption is very rapid in immature teeth. Therefore close endodontic monitoring is recommended. Teeth with open apices and a dry time longer than 60 minutes have a poor long-term prognosis. They should be managed similarly to teeth with closed apices

2.1.1.2 Patient instructions (Lars-Andersson *et al*., 2012)

Patient compliance with follow-up visits and home care contributes to satisfactory healing following an injury. Both patients and guardians of young patients should be advised regarding care of the replanted tooth for optimal healing and prevention of further injury.

• Avoid participation in contact sports.

• Soft diet for up to 2 weeks. Thereafter normal function as soon as possible

• Brush teeth with a soft toothbrush after each meal

• Use a chlorhexidine (0.1%) mouth rinse twice a day for 1 week.

2.1.1.3 Follow-up (Lars-Andersson *et al*., 2012).

• Splint removal and clinical and radiographic control after 2 weeks
• Root canal treatment 7–10 days after replantation
• Clinical and radiographic control after 4 weeks, 3 months, 6 months, 1 year, and then yearly thereafter.

2.1.1.4 Favorable outcome

Closed apex. Asymptomatic, normal mobility, normal percussion sound. No radiographic evidence of resorption or periradicular osteitis: the lamina dura should appear normal **(Lars-Andersson *et al*., 2012).**

Open apex. Asymptomatic, normal mobility, normal percussion sound. Radiographic evidence of arrested or continued root formation and eruption. Pulp canal obliteration is to be expected **(Lars-Andersson *et al*., 2012).**

2.1.1.5 Unfavorable outcome

Closed apex. Symptomatic, excessive mobility or no mobility (ankylosis) with high-pitched percussion sound. Radiographic evidence of resorption

(inflammatory, infection-related resorption, or ankylosis-related replacement resorption). When ankylosis occurs in a growing patient, infraposition of the tooth is highly likely leading to disturbance in alveolar and facial growth over the short, medium and long term **(Lars-Andersson *et al.*, 2012).**

Open apex. Symptomatic, excessive mobility or no mobility (ankylosis) with high-pitched percussion sound. In the case of ankylosis, the crown of the tooth will appear to be in an infraposition. Radiographic evidence of resorption (inflammatory, infection-related resorption, or ankylosis-related replacement resorption) or absence of continued root formation. When ankylosis occurs in a growing patient, infraposition of the tooth is highly likely to occur leading to disturbance of alveolar and facial growth over the short, medium and long term. Loss of tooth **(Lars-Andersson *et al.*, 2012).**

Figure1.1: Management of avulsion. **A** Always hold the tooth by the crown and gently debride the root surface with saline. **B** The socket should be irrigated and clear of debris.
C Replant with firm pressure. The tooth will usually click back into position. **D** Splint with a flexible splint, such as composite and nylon fishing line, to allow some physiological movement. E Orthodontic appliances are extremely useful when splinting traumatized teeth. The wire should be passive and allow physiological movement. Placement of a wire through orthodontic brackets allows the splint to be removed and the mobility of the tooth assessed **(Angus and Richard,2008)**

3.1.1 Luxation injuries:

It includes concussion, subluxation, lateral luxation, extrusion, and intrusion.

3.1.1.1 Concussion

A concussion is a type of injury to the tooth and its supporting structures with an increased percussion that doesn't involve any asymmetrical disarticulation of the tooth. On examination plus radiographic findings suggested that the concerned tooth has high sensitivity on percussion but devoid of any increased mobility. There is no abnormality in radiographic findings **(Karishma *et al.*, 2020)**.

A. management of concussion

According to clinical guidelines there should be a record of the condition of the pulp of the tooth till 1 year. And according to orthodontic protocol, the patient needs to wait for 3-5 months to start any kind of orthodontic treatment. There has to be the maintenance of a record of radiographs throughout 1 year after trauma. In such cases, mild and intermittent forces can be used **(Karishma *et al.*, 2020)**.

B. Follow up (Angus and Richard, 2013)

•Pulp sensibility testing at 1, 3 and 12 months

•Radiographs at each review

•It is important to follow up these teeth for at least 12 months clinically, checking pulpal status, colour, mobility and radiographically assessing changes in the size of the pulp chamber and in root development.

C. Prognosis

Pulp necrosis in 3–6%.

3.1.1.2 Subluxation

Subluxation is a type of injury where the supporting structures of the tooth along with unusual loosening of tooth takes place, however, there will be no displacement of the tooth to be found. According to clinical findings, the concerned tooth will be having tooth sensitivity along with an increase in the grade of mobility. Also, there will be bleeding in the gingival crevice in this case but there will be no abnormalities in radiographic findings **(Karishma *et al.*, 2020)**.

A. Management of subluxation (Diangelis *et al.*,2012)

1. a flexible splint for patient comfort can be placed for up to 2 weeks.
2. To relieve occlusal interferences, glass ionomer cement can be applied to the occlusal surface of the molars to open the bite temporarily.
3. A soft diet for 2 weeks is recommended.

B. Follow up (Angus and Richard, 2013)

•Pulp sensibility testing at 1, 3 and 12 months

•Radiographs at each review

•It is important to follow up these teeth for at least 12 months clinically, checking

pulpal status, colour, mobility and radiographically assessing changes in the size of the pulp chamber and in root development.

C. Prognosis

Pulp necrosis in 3–6%.

3.1.1.3 Lateral luxation

When the tooth is displaced in a particular direction other than axially then the displacement of the tooth is called lateral luxation which is associated with comminution or the fracture of the alveolar socket. In this case, clinical findings like the displacement of the tooth take place buccally or lingually/palatally which is immobile as well as tender on percussion that gives a metallic sound.

The immature teeth will have revascularization of pulp. The radiographic examination in this case will show an increased space in the periodontal ligament area apically wide in an occlusal radiographic view **(Karishma *et al.*, 2020)**

A. management of lateral luxation (Angus and Richard, 2013)

1.Repositioning with local anaesthesia. Early repositioning is important as it is often extremely difficult to mobilize the tooth if the patient presents after 24 hours.

2.Suture gingival lacerations.

3.Flexible splinting with composite resin, and wire or orthodontic appliances,4 weeks .

4.Antibiotics, tetanus prophylaxis, and 0.2% chlorhexidine gluconate mouth rinse if required.

If we see the protocols of orthodontics criteria then, the patient should wait for 6 months, to begin with, the orthodontic treatment. And during orthodontic treatment, radiographic control has to be performed every 3 months. Mild as well as intermittent forces has to be used. If necessary then the orthodontic treatment should be simplified **(Karishma *et al.*, 2020).**

Figure 1.2: management of lateral luxation **(A)** Lateral luxation (palatal) with a dentoalveolar component involving the upper right central and lateral incisors. **(B)** The block of teeth and bone is manually replaced with finger pressure. **(C,D)** A rigid composite resin and wire splint is placed. When placing a splint, attach and stabilize uninvolved teeth before splinting the displaced segment.**(Angus and Richard, 2013)**

B. Follow up (Angus and Richard, 2013)

•Review every 2 weeks while the splint is in place, then 1, 3, 6 and 12 monthly up to 5 years.

•Pulp sensibility testing

. •Radiographs at each visit

C. Prognosis (Angus and Richard, 2013)

Dependent on the degree of displacement and apical development, with excellent healing in immature teeth.

Pulp necrosis occurs in 15–85% of cases and is more prevalent in teeth with closed apices.

Pulp canal obliteration often occurs in teeth with immature apices.

Resorption is rare.

Transient apical breakdown (2–12%) is an expansion of the apical periodontal ligament space. There is no indication for starting root canal treatment, unless .there are other indicators of infection of the pulp canal.

3.1.1.4 Extrusive luxation

Extrusive luxation also known as peripheral dislocation or partial avulsion. It refers to the incomplete dislocation of the tooth that is exposed out of its jaw socket. According to the clinical signs there will be an elongated tooth that will be excessively mobile. The immature teeth will have revascularization of pulp. The radiographic examination in this case will show an increased space in the periodontal ligament area apically **(Karishma *et al*., 2020).**

A. Management of extrusive luxation

according to clinical protocol there should be the relocation of the tooth into its jaw socket to be done very gently. By using a flexible splint, stabilization of the tooth can be done for 2 weeks by utilizing flexible splint while keeping an eye on the condition of pulp and radiographic control for 5 years If we stick to the protocols of orthodontics criteria then, the patient should wait for 6 months to begin the orthodontic treatment. And during orthodontic treatment, radiographic control has to be performed every 3 months. Mild as well as intermittent forces has to be used. If necessary then the orthodontic treatment should be simplified.

(Karishma *et al.*, 2020).

B. follow up after treatment (Angus and Richard, 2013)

•Review every 2 weeks while the splint is in place, then 1, 3, 6 and 12 monthly up to 5 years.

•Pulp sensibility testing

. •Radiographs at each visit

C. Prognosis

Dependent on the degree of displacement and apical development, with excellent healing in immature teeth .Pulp necrosis occurs in 15–85% of cases and is more prevalent in teeth with closed apices .Pulp canal obliteration often occurs in teeth with immature spices and Resorption is rare.

Transient apical breakdown (2–12%) is an expansion of the apical periodontal ligament space. There is no indication for starting root canal treatment, unless there are other indicators of infection of the pulp canal **(Angus and Richard, 2013).**

3.1.1.5 Intrusive luxation (central dislocation)

The least common displacement injury in the permanent dentition is known as central dislocation or intrusive luxation where dislocation of the tooth into the alveolar bone occurs. Such type of wound is combined with the fracture of alveolar bone. If we see the clinical findings then, the displacement of the tooth takes place buccally or lingually/palatally which is immobile as well as tender on percussion that gives a metallic sound. The immature teeth will have revascularization of pulp. The radiographic examination in this case will show an absence or partial absence of the periodontal space in an occlusal radiographic examination **(Karishma et al., 2020).**

A. Treatment of intrusive luxation

- Teeth with incomplete root formation (Diangelis *et al*., 2012)

• Allow eruption without intervention

• If no movement within few weeks, initiate orthodontic repositioning

• If tooth is intruded more than 7 mm, reposition surgically or orthodontically

- Teeth with complete root formation (Diangelis *et al*., 2012)

• Allow eruption without intervention if tooth intruded less than 3 mm. If no movement after 2–4 weeks, reposition surgically or orthodontically before ankylosis can develop.

• If tooth is intruded beyond 7 mm, reposition surgically

• The pulp will likely become necrotic in teeth with complete root formation. Root canal therapy using a temporary filling with calcium hydroxide is recommended and treatment should begin 2–3 weeks after surgery

• Once an intruded tooth has been repositioned surgically or orthodontically, stabilize with a flexible splint for 4–8 weeks

B. Follow up (Angus and Richard, 2008)

It is essential that these teeth are regularly followed up. Progressive inflammatory resorption occurs very rapidly and an immature tooth may be lost within a number of weeks..

Review every 2 weeks during mobilization phase, then at 6–8 weeks, 6 months, 12 months and yearly for 5 years.

C. Prognosis (Angus and Richard, 2008).

1.Mature teeth undergo pulp necrosis in almost all cases (96%), and there is a high prevalence of root resorption and ankylosis.

2.Immature teeth that re-erupt show pulp necrosis in 60% of cases and ankylosis in up to 50% of cases

3. Teeth treated early have a much better prognosis.

4.1 splinting of injured teeth

Splinting has been advocated after repositioning of a tooth/teeth to stabilize the tooth/teeth and to optimize healing outcomes for the pulp and/or the periodontal ligament **(Oikarinen et al., 2007)** A splint has been defined as ‘an apparatus used to support, protect or immobilize teeth that have been loosened, replanted, fractured or subjected to certain endodontic surgical procedures ‘ **(B Kahler et al., 2016)**, many types of splints have been used and ideally should meet the following requirements which have been modified from Andreasen's original recommendations in 1972.**(Andreasen, 1972)** A splint should:

1. Allow periodontal ligament reattachment and prevent the risk of further trauma or swallowing of a loose tooth.

2. Be easily applied and removed without additional trauma or damage to the teeth and surrounding soft tissues.
3. Stabilize the injured tooth/teeth in its correct position and maintain adequate stabilization throughout the splinting period.
4. Allow physiologic tooth mobility to aid in periodontal ligament healing.
5. Not irritate soft tissues.
6. Allow pulp sensibility testing and endodontic access.
7. Allow adequate oral hygiene.
8. Not interfere with occlusal movements.
9. Preferably fulfill aesthetic appearance.
10. Provide patient comfort.

5.1Types of splints available:

5.1.1 Composite and wire splints

Composite and wire splints are perhaps the most commonly used in clinical practice and are flexible splints when the wire has a diameter of no greater than 0.3–0.4 mm.**(Oikarinen, 1988)** An example of a wire and composite resin splint is shown in Fig.3

Figure 1.3: A composite resin and wire splint. **(B Kahler *et al.*, 2016)**

5.1.2 Composite and fishing line splints

An alternative to wire is where fishing line replaces wire and the line is secured with composite resin.

5.1.3 Orthodontic wire and bracket splints

This splint, which is extensively employed by pedodontists in Australia, involves orthodontic brackets bonded to the teeth with a resin-based orthodontic cement and connected with a light 0.014 NiTi flexible wire. An example of this splint is shown in Fig.4 where the patient has sustained traumatic injuries to the maxillary right central and lateral incisors and the maxillary right central incisor. Orthodontic bracket splints allow teeth that have been intruded or not repositioned correctly to have the occlusal relationships modified at a later date**(Dawoodbhoy *et al*., 1994; Mackie et al.,1998)**

Figure 1.4: An orthodontic wire and bracket splint **(B Kahler et al., 2016)**

5.1.4 Fibre splints

Fibre splints use a polyethylene or Kevlar fibre mesh and are attached either with an unfilled resin and/or with composite resin Materials such as Fiber-Splint are commercially available. An example of a Fiber-Splint is shown in Fig.5 following an avulsion injury of the maxillary left central and lateral incisor teeth. **(Andreasen et al.,2004).**

Figure 1.7: Application of a fibre splint bonded with the unfilled resin OptiBond to splint an avulsed maxillary left central and lateral incisor **(B Kahler *et al.*, 2016)**

5.1.5 Titanium trauma splints

The titanium trauma splint developed by von Arx **(Von Arx *et al.*,2001)** is a flexible splint made of titanium, 0.2 mm thick and 2.8 mm wide (Medartis AG, Basel, Switzerland). It has a rhomboid mesh structure which is secured to the tooth with flowable composite resin. A disadvantage of this splint type is its relatively high cost. In this application composite resin was used instead of flowable resin in (Fig.6a) The patient initially presented with an arch bar splint which was . replaced with a titanium trauma splint because of gross irritation to the gingival tissues (Fig.6b)

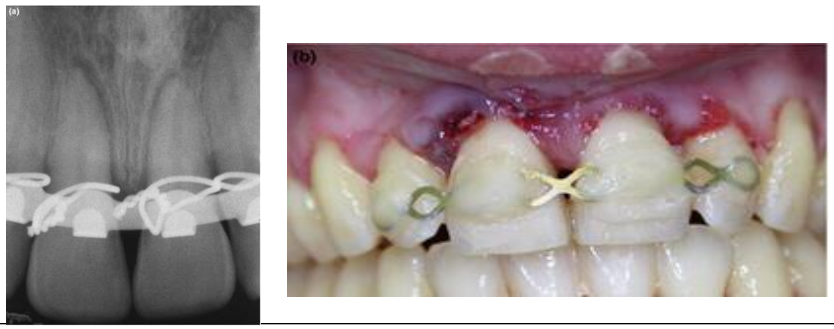

Figure 1.6: (a) Radiograph of an arch bar secured by wire ligatures. **(b)** The arch bar and ligature splint has been replaced with a titanium trauma splint. Gross gingival irritation caused by the arch bar splint is evident **(B Kahler et al., 2016)**

5.1.6 Arch bar splints

Arch bar splints were initially adopted for maxillary and mandibular fractures in the 1870s and adapted for dentoalveolar trauma **(Oikarinen, 1990)** A metal bar is bent into the shape of the arch and fixed with ligature wires.

Disadvantages of this technique are that this type of splint is rigid and arch bars may loosen and cause irritation. There may also be physical damage from the ligature wires to the gingival tissues and the integrity of the cemento-enamel junction **(Oikarinen, 1988)** As stated earlier, an example of an arch bar splint is seen in Fig.6 a. The degree of gingival irritation is seen in Fig.6 b.

5.1.7 Wire ligature splint

Wire ligature splints are sometimes used by oral surgeons in clinics where dental splinting materials may not be available and examples are shown in Figs.7. These splint types are generally rigid and impinge on the gingival tissues with resulting inflammation, as seen in Fig.7c taken immediately after splint removal **(B Kahler *et al.*, 2016).**

Figure 1.7: (a) Interproximal wiring has been applied to splint a transversely fractured maxillary left central incisor. Not only has the fractured tooth been poorly repositioned, but early gingival tissue irritation is apparent. **(b)** Radiograph of fractured maxillary left central incisor in Fig. 7a showing evidence of poor apposition of the fractured segments. **(c)** Gingival laceration and inflammation was evident on removal of the splint. **(d)** A radiolucency at the fracture site, coupled with clinical symptoms led to a diagnosis of an infected root canal system in the coronal segment associated with inflammation at the fracture site. Endodontic treatment of the coronal segment to the level of the fracture site was instigated. **(B Kahler *et al.*, 2016)**

5.1.8 Composite splints

Resin composite applied to the surfaces of teeth is a rigid splint and accordingly is not recommended in the IADT guidelines .However, Fig.10 is an example of a composite resin splint applied to the labial surfaces of the maxillary right central incisor and adjacent teeth. Composite splints that are bonded interproximally to adjacent teeth are also reported to be prone to fracture **(Oikarinen, 1990)** Furthermore, composite splints resulted in greater gingival irritation when compared with wire and composite, an orthodontic bracket splint or the titanium trauma splint **(Filippi *et al.*,2002).**

Figure 1.8: A rigid composite splint has been applied to the labial surface of the maxillary right central incisor and adjacent teeth **(B Kahler *et al.*, 2016)**

6.1 Trauma during Orthodontic Treatment

Teeth experiencing trauma during orthodontic treatment are significantly more likely to have pulpal necrosis than orthodontic or trauma only teeth **(Bauss *et al.*, 2009)**. Furthermore, teeth with extrusion, intrusion, or lateral luxation were significantly more likely to have pulpal necrosis than teeth experiencing injury only to the crown **(Bauss *et al.*, 2009)**.

Total pulpal obliteration appeared to be another significant factor in pulpal necrosis. Certainly monitoring these teeth at defined intervals with radiographs is indicated.Although there is no evidence to provide the clinician with

definitive answers, the prudent clinician will reassess the case after the traumatic injury. Depending on the extent of the injury and the current stage of treatment (beginning, middle, and finishing), the clinician may elect to discontinue treatment, modify treatment, or finish as planned **(Henry and John, 2013).**

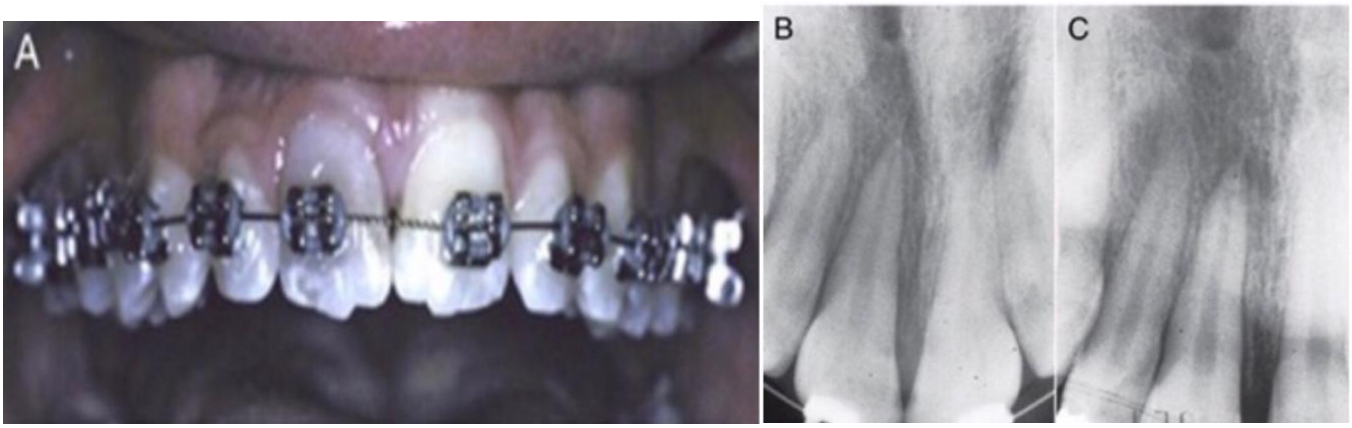

Figure 1.9: Patient experienced a concussion injury to the maxillary right central incisor while undergoing orthodontic treatment. **(*A*)** The archwire was changed to a lighter wire, the tooth was stabilized, and the radiograph revealed no pathology. Treatment progress continued within several weeks. **(*B* and *C*)** Follow-up radiographs revealed periapical pathology when exposed from multiple vertical angles. **(Henry and John, 2013).**

7.1 prevention of dental injuries:

1. the incidence of traumatic dental injuries increased with Class II malocclusions, therefore; Preventive measures should include early correction of al cases with significant overjet and lip incompetence.
2. early orthodontic treatment for children with prominent upper front teeth is more effective in reducing the incidence of incisal trauma than providing one course of treatment when the child is in early adolescence.
3. Athletic mouth guards should be used for contact sports and can be fabricated to accommodate fixed orthodontic appliances, tooth movement, and exfoliation-eruption processes in the mixed dentition **(Graber, 2017).**

Chapter two

Discussion/comments

Currently, all of the studies on the treatment of traumatically injured permanent teeth have limitations and the proposed guidelines for treatment are not based on strong evidence. The most important points to be discussed were the degree of root development, the degree of tooth mobility, the maintenance of pulpal vitality, and the treatment time **(Martins *et al.*,2007; Elbay *et al.*,2017).**

splinting of teeth utilized the principles of jaw bone fracture with rigid, long-term immobilization for a few months**(Kehoe, 1986)** The validity of this approach was questioned when studies showed rigid immobilization increased the incidence of pulp necrosis**(Kristerson , 1983)** and external root resorption**(Kristerson and Andreasen, 1983; Andreasen, 1975).** The use of flexible splints arose when animal experimentation reported a lower incidence of ankylosis when teeth were subjected to masticatory forces,**(Andersson et al., 1985)** which suggested that splints should provide some functional movement of the traumatized teeth. A flexible splint allows functional movement in contrast to a rigid splint where the injured teeth are immobilized. A recent systematic review and meta-analysis on autotransplanted teeth reported that the ankylosis rate was three times higher with wire and composite resin splinting when compared with suture splinting, suggesting the importance of physiological movement on healing outcomes**.(Chung et al., 2014)** Another study showed that teeth splinted for just 1 week were clinically firm,**(Andreasen, 1975)** which indicated shorter splinting times could be considered. As a consequence of these and other studies, the International Association of Dental Traumatology (IADT) guidelines recommend splinting types that are flexible rather than rigid and employed for shorter duration**(DiAngelis et al., 2012)**.

Chapter three
Conclusions and Suggestions

The IADT (International Association of Dental Trauma) provided well defined guidelines in dental trauma treatment, and by following these guidelines, it is possible to reach a stable result. Nevertheless, analyzing each aspect of the injury allows to optimize the treatment plan for each patient, and to understand how forces and their direction can outline the different trauma treatment outcome.

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