DENTAL TRAUMA

- Tooth that has been knocked out starts to die within 15 minutes (if not placed in milk).
- Most dental traumas occur in [7—12 years old] due to falls and accidents near home/school. It occurs primarily in **anterior region** and affects **maxillary** more than mandibular.
- Overjet of **>3mm** increases likelihood of dental trauma. If the overjet is **>9mm** the risk doubles.
- 97% of all injuries occur in the incisors according to the following distribution:

	R. Lateral	R. Central	L. Central	L. Lateral
Maxillary	5%	34%	34%	5%
Mandibular	3%	6%	6%	3%

Electric and Thermal Tests

- Traumatized teeth that yield no response from EPT or thermal test **cannot** be assumed to have necrotic pulps (chance of false-negative reading)
- Traumatized teeth that give response to thermal and electric tests **cannot** be assumed to be healthy or that they will continue to give a response over time.

➔ Repetitious tests must be done overtime to conclude the state of the pulp.
a transition from -ve response to +ve response (at a subsequent test) is a sign of a healing pulp
a transition from +ve response to -ve response (at a subsequent test) is a sign of a necrotic pulp

- EPT and thermal test of **all upper & lower anteriors** should be recorded at time of injury and shall be repeated at **[3 weeks – 3,6,12 months]**.

Percussion Test

- Normal teeth have **dull** sound on percussion
- **Metallic** sound and absence of normal mobility: ankylosis or locking – Intrusion & Lateral Luxation.
- Erupted tooth with an impacted tooth against it will have a **solid** sound to percussion

Radiographic Examination

- To take a soft-tissue radiograph, use a normal-sized film and briefly expose it at a **reduced kilovoltage.**
- The injured area should reveal presence of many foreign substances including tooth fragments.

Follow-up

- After the splinting period is completed, follow-up is as for all dental traumatic injuries: **3,6** and **12 months** then **yearly** thereafter.

Crown Fractures

Crown Infraction

- Incomplete fracture or crack in enamel without loss of tooth structure.
- Generally, enamel infractions require no treatment. However, severe cases of multiple infraction lines require sealing the enamel surface with an adhesive to prevent taking up stains.

Uncomplicated Crown Fracture

- Fracture of enamel only or enamel and dentin **without** pulp exposure.
- Most common (1/3 to 1/2 of all dental injuries)
- Minor danger of pulpal necrosis. However, the biggest danger to pulpal health is during aesthetic restoration of the tooth.
- Exposed dentinal tubules need to be closed as soon as possible by:
    - **Fragment Reattachment**
        - Advantages:
            - Immediate hermetic seal of dentinal tubules
            - Immediate restoration of function and esthetics
            - Short treatment time
        - Steps:
            - Fragment Attachment

                - 2” long stick, 2mm in diameter with an adhesive tip on one end. Apply light pressure to pick-up small items for easy handling. To release, twist the stick gently.
                - Etch both the broken tooth and its fragment.
                - Apply bonding agent on both and cure while holding them firmly against each other.
            - Masking Fracture Line
                - Remove any excess of (composite resin??) with discs
                - Remove 1-mm gutter of enamel on each side of the fracture line both labially and palatally to a depth of 0.5mm using a small **round** or **pear-shaped bur**. The finishing line should be **irregular** in outline.
                - Etch the newly prepared enamel then apply bonding agent and composite.
                - Finish & Polish
    - **Composite Restoration**
        - RDT < 0.5mm ➔ Apply a protective layer of hard-setting $Ca(OH)_2$ in the deepest part of dentin.
        - RDT > 0.5mm ➔ Restore with restoration of choice.
            - $Ca(OH)_2$ is not used here because is reduces strength of fragment bonding.

- **Temporary Coverage**
  - The entire fracture surface is covered with GIC and a composite is placed for approximately 1 month.
  - Fragment is kept moist in physiologic saline (should be changed weekly).
  - Incase the fragment was left dry, wet storage for 24 hours may normalize the situation.

Complicated Crown Fracture

- Involved enamel, dentin, and pulp. If left untreated, pulp necrosis always results.
- Treatment options:
  - **Vital Pulp Therapy**
    - Requirements for Success:
      - Treatment of a non-inflamed pulp; Optimal time for treatment is within **24-hours** since pulp inflammation is superficial. As time between injury and therapy increases, pulp removal must be extended apically.
      - Bacteria-tight seal
      - Pulp dressing: bioceramic materials are considered the agents of choice. *MTA 1st Generation* doesn't enjoy the same popularity as $Ca(OH)_2$ *because older MTA's caused discoloration (from **bismuth oxide**). Newer generation ones are superior to $Ca(OH)_2$ and don't cause any discoloration.*
    - Methods:
      - Pulp Capping: Success rate is (**80%**) compared to partial pulpotomy (**95%**) because superficial inflammation develops soon after traumatic exposure and because **bacteria-tight coronal seal** is much more difficult to attain in superficial pulp capping because there is **no depth** to the cavity to aid in creating the seal.

      - Partial Pulpotomy: Partial removal of coronal pulp tissue to the level of healthy pulp. **Notes**:
        - Anesthetic without vasoconstrictor.
        - Avoid slow-speed bur/spoon-excavator.
        - If bleeding is excessive, pulp is amputated deeper until only moderate hemorrhage is seen.
        - Rinse pulpal wound with NaOCl
        - Do not allow a blood clot to develop

      - Full Pulpotomy: Removal of the entire coronal pulp to a level of the root orifices. Indicated when traumatic exposure is more than 72 hours or when carious exposure of a young tooth with partially developed apex. **It is contraindicated in mature teeth and emergencies (symptomatic irreversible pulpitis ➔ no time)** however, it may be used as an interim treatment until patient decides for extraction or complete RCT.

- **Pulpectomy**
  - Indications:
    - Complicated crown fracture of mature teeth if conditions not ideal for vital pulp therapy or if it is foreseeable that restoring the tooth would require a post.
    - Necrotic immature teeth: lack of apical stop, thin dentinal walls.
  - Immature: Pulpectomy: Apexification
    - WL determination ➔ very light filing with 0.5% NaOCl irrigation ➔ Dry canal ➔ Creamy mix of $Ca(OH)_2$ spun into the canal and packed against apical soft tissue with a plugger or thick paper point. ➔ Leave for **1—4 weeks** ➔ Placement of thick/powdery mix.
    - Radiographic evaluation at **3-months** intervals: check if hard tissue barrier has formed or if $Ca(OH)_2$ has washed out of the canal. If no washout is evident, it can be left intact for another 3 months. Avoid excessive dressing changes because the initial toxicity of material delays healing.
    - When completion of hard tissue barrier is suspected: $Ca(OH)_2$ is washed out with NaOCl ➔ File can be used to gently probe for a stop at the apex. When a hard tissue barrier is indicated radiographically, the canal is ready for obturation. Avoid excessive lateral force during obturation, owing to the thin walls of the root.
    - Formation of hard tissue barrier might be some distance away from the radiographic apex because the barrier forms wherever $Ca(OH)_2$ contacts vital tissue.
  - Immature: Pulpectomy: Immediate Apexification
    - Disinfect canal ➔ Place Calcium Sulfate through the apex as a barrier against which MTA is placed ➔ A 4mm MTA plug is placed at the apex ➔ Canal is obturated ➔ Bonded resin is placed below CEJ to strengthen root.
- **Revitalization**
  - Indications
    - Avulsed immature tooth
    - Necrotic immature tooth
  - Treatment includes application of a mixture of *ciprofloxacin, metronidazole,* and *minocycline*. At 24-month checkup, continued root development can be seen in length and width of the root.

- The choice of treatment depends on:
    - Stage of tooth development: In an immature tooth, every effort is made to keep it vital, **atleast until complete root development.**
      Mature teeth have extremely high success rate in pulp removal, and under optimal conditions, vital pulp therapy (rather than removal) can be carried out.

    - Time between trauma and treatment: For **48-hours** (next slide [34] it is written 24-hours) after a traumatic injury, the reaction of the pulp is proliferative, with no more than 2-mm depth of pulpal inflammation.
      After 48-hours, chances of direct **bacterial contamination** of the pulp increase, with the zone of inflammation progressing apically.
      Generally, the more time, the less the likelihood of maintaining a health pulp.

    - Concomitant periodontal injury: A periodontal injury compromises the nutritional supply of the pulp. This is important for mature teeth which have a less chance of pulpal survival than immature teeth.

    - Restorative treatment plan: If the treatment plan of a **mature tooth** is simple, such as composite resin restoration, vital pulp therapy is the treatment of choice.
      If the treatment plan involves a more complex restoration (crown, bridge, etc..) pulpectomy is favored.

Crown Root Fracture

- Tooth must be treated periodontally to enable a well-sealed coronal restoration. This could be accomplished by simple gingivectomy if the event of the root component of the fracture is large. Alternatively, tooth can be orthodontically or surgically extruded such that the exposed surface of the root surface is treatable. Once the feasibility of the coronal restoration is assured, the crown fracture is treated as previously described.

Root Fracture

- Fracture of cementum, dentin, and pulp. Less than 3% of all dental injuries.
- Immature teeth with <u>vital</u> pulps rarely sustain horizontal root fractures.
- When a root fractures horizontally, the coronal segment is displaced to a varying degree, but generally, the apical segment is not displaced because the apical circulation is not disrupted.
- Pulp necrosis in the apical segment is extremely rate, however, pulpal necrosis in the coronal segment occurs in about 25% of cases.
- Radiographic examination for root fractures is important. Because root fractures are oblique (facial to palatal), It is imperative to take atleast 3 angled radiographs [**45, 90** and **110**] so that atleast at one angulation the x-ray beam passes through the fracture line.
- **Treatment**: Emergency treatment involves repositioning the segments into close proximity as much as possible and semi-rigid splint to adjacent teeth for 2-4 weeks. In case of severe displacement of the coronal segment, release the coronal segment from the bone by gently pulling it downward with finger pressure or extraction forceps ➔ Rotate it back to its original position.

- If a long time has elapsed between the injury and treatment, repositioning the segments close to their original position probably will not be possible.
- **Prognosis – Factors Influencing Repair: -**
    - Degree of dislocation/mobility of the coronal fragment
    - Immature teeth are seldom involved in root fractures, but their prognosis is good.
    - Quality of treatment; the prognosis improves with quick treatment, close reduction of the segments and semi-rigid splinting for 2—4 weeks.
- <u>Healing Patterns of Root Fractures</u>:

Healing with calcified Tissue	**Healing with interproximal connective tissue**	**Healing with interproximal bone and connective tissue**	**Inflammatory tissue without healing**
Radiographically, Fracture line is radiopaque. 	Radiographically, fragments appear separated by radiolucent line, and fractured edges appear rounded. 	Radiographically, the fragments are separated by a distinct bony ridge. 	Radiographically, a widening of the fracture line and/or a developing radiolucency corresponding to the fracture line. This is typical when the coronal segment loses its vitality. The infective products in the coronal pulp cause an inflammatory response and radiolucencies at the fracture line. 

Coronal Root Fractures

- If the coronal segment is adequately splinted, chances of healing do not differ from those for mid-root or apical fractures. However, if the fracture occurs at the level of the crest of the alveolar bone, the prognosis is extremely poor.
- If re-approximation of the fractured segments is not possible, extraction of the coronal segment is indicated. The level of fracture and length of the remaining root are evaluated for restorability. Gentle **orthodontic eruption** of the segment can be carried out to enable fabrication of a restoration.

Mid-Root Fractures

- In many cases, the pulp in the coronal segment will become necrotic after the injury. However, because of a very large apical opening in the coronal segment, revascularization is possible if the segments are well re-approximated.
- If there was no periapical pathology, endodontic treatment is indicated in the coronal root segment.
- In most cases, pulpal lumen is wide at the apical extend of the coronal segment ➔ long-term $Ca(OH)_2$ treatment or MTA apical plug is indicated. The coronal segment is filled after a hard tissue barrier has formed apically in the coronal segment.
- Treatment options:
    - Repositioning and splinting
    - Disinfection and obturation of the coronal segment only. (Necrosis is rare for apical part)
    - If both segments undergo necrosis:
        - Endodontic treatment for both segments
        - Extraction of apical segment and endodontic treatment of the coronal segment
    - Intra-radicular splinting
    - Removal of the apical segment and stabilization of the coronal with endodontic implant

Apical Root Fractures

- Usually require no immediate treatment, but must be observed for long term

Summary

Injury	Diagnosis	Simple	Complicated
Crown Infraction	Crack in enamel without loss of tooth structure **Complicated: multiple fracture lines**	No treatment	Seal enamel surface with adhesive to prevent taking up stains.
Crown Fracture	Simple: Fracture of enamel and/or dentin without pulp exposure **Complicated: involves pulp and always result in pulpal necrosis if left untreated.**	1. Fragment Reattachment 2. Composite Restoration 3. Temporary Coverage	1. Vital Pulp Therapy a. Pulp capping b. Partial pulpotomy c. Full pulpotomy 2. Pulpectomy a. Mature Teeth b. Immature: Apexification c. Immature: Immediate Apexification 3. Revitalization Choice of treatment depends on tooth development, time between trauma and treatment, periodontal injury, and restorative treatment plan.
Crown Root Fracture	Tooth must be treated periodontally to enable a well-sealed coronal restoration. This could be accomplished by simple gingivectomy if the event of the root component of the fracture is large. Alternatively, tooth can be orthodontically or surgically extruded such that the exposed surface of the root surface is treatable. Once the feasibility of the coronal restoration is assured, the crown fracture is treated as previously described.		
Root Fracture	Fracture of cementum, dentin, and pulp	Emergency treatment involves repositioning the segments into proximity as much as possible and semi-rigid splint to adjacent teeth for 2-4 weeks	In case of severe displacement of the coronal segment, release the coronal segment from the bone by gently pulling it downward with finger pressure or extraction forceps ➔ Rotate it back to its original position. **Coronal Root Fracture**: If reapproximation of the fractured segments is not possible, extraction of the coronal segment is indicated. The level of fracture and length of the remaining root are evaluated for restorability. If the apical root segment is long enough, gentle orthodontic eruption of this segment can be carried out to enable fabrication of a restoratio **Mid-Root Fractures** • Repositioning and splinting • Disinfection and obturation of the coronal segment only. (Necrosis is rare for apical part) • If both segments undergo necrosis: ○ Endodontic treatment for both segments ○ Extraction of apical segment and endodontic treatment of the coronal segment • Intra-radicular splinting • Removal of the apical segment and stabilization of the coronal with endodontic implant • Endodontic treatment is indicated in the coronal root segment only unless periapical pathology is seen. In most cases the pulpal lumen is wide at the apical extent of the coronal segment, and long-term calcium hydroxide treatment or an MTA apical plug is indicated. The coronal segment is filled after a hard tissue barrier has formed apically in the coronal segment. **Apical Root Fractures** No immediate treatment but must be observed for long time

Luxation Injuries

Concussion, subluxation, and other luxation injuries.

More intense injury and subsequent sequelae →

	Concussion	**Subluxation**	**Lateral Luxation**	**Extrusive Luxation**	**Intrusive Luxation**
			Most common of all dental injuries with incidence ranging from **30%** – **40%**		
Displacement	No	No	Displacement in a direction other than axially (labially/lingually)	Displacement in a coronal direction	Displacement in an apical direction into the alveolus
Mobility	Normal	Increased			Immobile
Percussion	Sensitive	Sensitive			High percussion tone (metallic)
Development of Pulp Necrosis	Lowest	Some damage to neurovascular supply may happen	Severance of the neurovascular supply. Entrapment of apex		Highest
Damage to PDL and Cementum	Lowest	Separation of PDL, interstitial bleeding/edema	Communication of fracture of the alveolar socket		Highest. Gingival Bleeding.
Biologic consequences	Localized Injury: Healing with Cementum		Pulp Canal Obliteration (Calcification)		Diffuse Injury: Healing by Osseous Replacement
Treatment	Do not need any immediate treatment. Response to vitality tests should be investigated and noted. Even after **mild injury**, pulp might be **unresponsive** to vitality tests for several weeks if not months. When pulp is unresponsive initially after trauma, patients should be recalled on a regular basis and monitored for any additional signs of infection.		• Repositioning + physiologic splinting: **4-weeks** for lateral luxation and **2-weeks** for extrusion. • The apex might be perforating the facial bone plate, tooth must be slightly and gently pulled down to loosen the hold before repositioning. • RCT follows avulsion guidelines. (Endo treatment should be initiated 2-weeks after injury. If apex is not fully formed, wait for signs of revascularization)		**Permanent mature teeth** that are intruded (not likely to re-erupt) ➔ Orthodontic or Surgical extrusion. Orthodontic extrusion should not be delayed longer than **2—3 weeks**. In most cases splinting should be atleast **4-weeks.** RCT is indicated for intruded teeth except those with immature roots (pulp may revascularize). **Incomplete formed teeth with open apex** may reposition spontaneously.

Biologic Consequences

- **Favorable healing** after a luxation injury occurs if the initial physical damage to the root surface and the resultant inflammatory response are again covered with **cementum**.
- **Unfavorable response** occurs when there is direct attachment of bone to the root, with the root ultimately being replaced by bone.

<table>
<tr><th colspan="3">External Inflammatory Root Resorption
Recognized inflammatory stimuli that cause root resorption are pressure, pulp space infection, and sulcular infection</th></tr>
<tr><th colspan="2">A. Caused by injury (alone) to external root surface</th><th>B. Caused by injury to external root surface & Inflammatory stimulus in root canal.</th></tr>
<tr><th>A.1. Localized Injury: Healing with cementum</th><th>A.2. Diffuse injury: Healing with osseous replacement</th><th rowspan="2"></th></tr>
<tr><td>Localized traumatic injury (concussion or subluxation)</td><td>Severe traumatic injury (intrusive luxation or avulsion – extended dry time)</td></tr>
<tr><td>Local inflammatory response and localized area of root resorption.
If no further inflammatory stimulus is present, periodontal healing and root surface repair occur within 14 days.</td><td>Involves diffuse damage on >20% of root surface. Initial reaction (inflammation) result in diffuse root surface area devoid of cementum. Bone cells rather than the slower-moving PDL cells move across from the socket wall and populate the damaged root. Bone comes into contact with the root without an intermediate attachment apparatus in a phenomenon termed dentoalveolar ankylosis.
Osseous replacement cannot be reversed and can be considered a physiologic process. Root is resorbed by osteoclasts; bone slowly replaces the root.</td><td>Necrotic infected pulp provides stimulus for PDL inflammation. Because of the lack of cemental protection (trauma), the periodontal inflammation includes root resorption in addition to the expected bone resorption</td></tr>
<tr><td>Treatment is not required because in most cases it is symptomless and not even visualized radiographically. In minority of cases small radiolucencies can be seen on root surface that spontaneously repair. If the pulp responds to sensitivity tests, this is a clue that no treatment should be performed.</td><td>Treatment is by Minimizing the initial inflammation which is destructive in nature.
If Ledermix is placed in the root canal immediately after a severe trauma in which inflammation is expected, favorable healing occurs at a very high rate.</td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Apical Neurovascular Supply Damage</th></tr>
<tr><th>Pulp Canal Obliteration (Calcification)</th><th>Pulp Necrosis & Pulp Space Infection</th><th>Internal Root Resorption</th></tr>
<tr><td>Common after luxation injuries (mainly extrusive and lateral) and <u>inversely proportional</u> to pulp necrosis. More frequent in teeth with open-apices and those that has been rigidly splinted.</td><td>Factors most important: type of injury (concussion least, intrusion most) and stage of root development (mature apex > immature apex)</td><td></td></tr>
<tr><td>Mechanism is unknown. Theories:
1) Sympathetic or parasympathetic control of blood flow to the odontoblasts is altered, resulting in uncontrolled reparative dentin.
2) Hemorrhage or blood clot formation in the pulp after injury form a nidus for subsequent calcification if the pulp remains vital.</td><td rowspan="2">Because a serious injury is required for pulp necrosis, areas of <u>cemental</u> covering of the root usually are also <u>affected</u>. Bacterial toxins can pass through the dentinal tubules and stimulate an inflammatory response in PDL resulting in root and bone resorption.
Grey discoloration is more commonly associated with <u>pulp necrosis</u> following trauma.</td><td rowspan="2">Characterized by an oval-shaped enlargement of the root canal space. It is often misdiagnosed with External resorption which is <u>more common.</u>

Internal Root Resorption is:
- Usually Asymptomatic
- Granulation tissue
- Vital & Necrotic Tissue
- Lost/altered predentin and odontoblastic layer.</td></tr>
<tr><td>Calcific Metamorphosis
[Partial or Complete Radiographic Obliteration (not histologic)]

Respond to traumatic injury characterized by reduction in the size of radicular and coronal pulp spaces. Usually occurs in teeth with incomplete root formation. Trauma disrupts blood vessels entering the tooth causing pulpal infarction. The wide periapical foramen allows connective tissue from the PDL to proliferate and replace the infarcted tissue, bringing with it cementoprogenitor and osteoprogenitor cells capable of differentiating into cementoblasts, osteoblasts or both. <u>Complete radiographic obliteration</u> of the root canal does not necessarily mean the absence of pulp; in majority of cases it is present and <u>the pain threshold to thermal and electrical stimuli increases</u>; often the <u>teeth are unresponsive</u>. Palpation and percussion are usually within normal limits.</td></tr>
<tr><td>Calcific Metamorphosis usually causes a yellowish discoloration for the tooth. This can be treated by external bleaching of the enamel, but if that did not achieve a clinically successful result, <u>Intentional root canal treatment</u> may be performed to facilitate Internal bleaching. However, development of CM following trauma <u>DOES NOT</u> justify prophylactic root canal therapy.</td><td></td><td>Endodontic Treatment</td></tr>
</table>

Avulsion

Definition

- **Avulsion**: complete displacement of a tooth out of its socket.
- If visiting the dentist takes more than 1 hour, the tooth must be stored in a glass of milk or in the cheek.
- The **most** important factor to assure a favorable outcome after replantation is the **speed** which the tooth is replanted.

Consequences

- If the PDL left attached to the root surface does not dry out, the consequences are usually less.
- If excessive drying occurs before replantation, damaged PDL cells elicit a severe inflammatory response causing **Bone to directly attach onto the root surface** and replacement resorption takes place.
- Pulp necrosis **always** occurs after avulsion injury. If revascularization does not occur or effective endodontic therapy weas not carried out, the infected pulp and cemental damage results in **external inflammatory resorption** that can be very serious and lead to rapid loss of tooth.

Treatment Objectives

- Minimizing resultant inflammation due to the two main consequences of avulsion:
  - Attachment Damage
    - Treatment is directed at minimizing additional damage which happens due to drying
  - Pulpal Infection
    - All efforts are made to promote **revascularization** of the pulp (open apex). When revascularization fails (in the open apex tooth) or is **not possible** (in closed apex) all treatment efforts are made to prevent or eliminate toxins from root canal space (endo).

Management

Emergency Treatment at the Accident Site

- If doubt exists that the tooth could be replanted adequately, the tooth should quickly be stored in the appropriate medium until the patient can get to the dental office. Suggested storage media:
    - Hank's Balanced Salt Solution (HBSS, pH: 7.2) – superior ability to maintain the viability of the periodontal ligament fibers for extended periods. Should be available in emergency kits at homes and school.
    - Milk (cold)
    - Saliva (in mouth vestibule or in a container into which the patient expectorates)
    - Water (least desirable because the **hypotonic** environment causes rapid cell lysis).

Management in the Dental Office

- **Aim**: Attachment Apparatus; replant the tooth with a minimum of irreversible damaged cells (that will cause inflammation) and the maximal number of PDL cells that have the potential to regenerate and repair the damaged root surface.
- Emphasize on questions about when, how, and where the injury occurred.
- Recognize that a dental injury might be secondary to a more serious injury, rule out any injuries to the brain and/or CNS in general.
- Careful exploration of the **lip** wound should be performed to rule out any embedded tooth fragments or foreign body. This is accomplished by placing a dental film between the lips and dental arch and using **25%** of the normal exposure time.
- If the patient presents with the tooth out of the mouth, the storage medium should be evaluated, and the tooth should be placed in a more appropriate medium if required.
- If the tooth was replanted at the site of injury, the position of replanted tooth is assessed and adjusted if necessary.
- **Simply:** Prepare socket, prepare root, replant, construct a functional splint.

<table>
<tr><th>Prepare Socket</th><th>Prepare Root</th><th>Replant</th><th>Splint</th></tr>
<tr>
<td rowspan="5">Emphasis is placed on removal of obstacles in the socket.
It should be lightly aspirated if a blood clot is present. If the alveolar bone has collapsed or may interfere with replantation, a blunt instrument should be inserted into the socket to reposition the wall.

Socket is examined and rinsed with saline. A radiograph is taken, and adjacent teeth should be examined.</td>
<td>Depends on (a) maturity of the tooth and (b) dry time of the tooth before it was placed in a storage media.
A dry time of 60 minutes is considered the point where survival of PDL cells is unlikely</td>
<td rowspan="5">Replant gently into correct position and orientation. Assure using a radiograph.</td>
<td rowspan="5">Semirigid (physiologic) fixation: 1-2 weeks. The splint should have no memory (so tooth does not move during healing) and should not impinge on the gingiva and/or prevent maintenance of oral hygiene.
Use a radiograph to verify the positioning of the tooth. 1 week is sufficient to create periodontal support.
Therefore, the splint should be removed after 1—2 weeks. The only exception is with avulsion in conjunction with alveolar fractures ➔ splint for 4—8 weeks</td>
</tr>
<tr>
<td>Extraoral Dry Time Less Than 60 Minutes: Closed Apex
Rinse debris with saline and replant gently.
Root surface consists of some cells with the potential to regenerate and others that will act as inflammatory stimulators
Revascularization is not possible but chance for periodontal healing exists.</td>
</tr>
<tr>
<td>Extraoral Dry Time Less Than 60 Minutes: Open Apex
Gently rinse off debris with saline ➔ soak in doxycycline for 5 minutes or cover with minocycline ➔ replant.
Revascularization and continued root development are possible.</td>
</tr>
<tr>
<td>Extraoral Dry Time More Than 60 Minutes: Closed Apex
Remove PDL by placing in acid for 5 minutes ➔ soak in 2% stannous fluoride ➔ replant.
Endodontics can be performed extraorally. Root is prepared to be as resistant to resorption as possible. Acid was used to remove remaining tissue that would initiate an inflammatory response.</td>
</tr>
<tr>
<td>Extraoral Dry Time More Than 60 Minutes: Open Apex
If the decision were to replant the tooth, treat as with closed apex.
It is advantageous to perform endodontic treatment and apexification extraorally.</td>
</tr>
</table>

Note: Enamel Matrix Protein (**Emdogain**) was used in cases with extended extraoral dry times to make the root more resistant to resorption and stimulate formation of new PDL. Unfortunately, recent studies have shown that the positive effect is only temporary and most of these teeth start to resorb after few years.

Adjunctive Therapy

- **Tetanus Booster (Important)**: Patient should be sent to a physician for consultation regarding a tetanus booster within **48 hours** of the initial visit.

- **Systemic Antibiotics**: at the emergency visit and continuing until splint is removed.
    - Children ≤ 12 years with tetracycline staining risk: Penicillin V at an appropriate dose for patient age and weight.
      Adult: 1000mg loading dose followed by 500mg 4 times daily for 7 days.
    - Children > 12 years with little risk of staining: Doxycycline 2 times daily for 7 days at the appropriate dosage for patient age and weight.

- **Analgesics**: The need for analgesics should be assessed on individual case basis. The use of pain medication stronger than OTC NSAIDs is unusual. The following Flexible Analgesic Strategy:
    - Aspirin-like drugs indicated:
        - Mild pain: Ibuprofen 400 – 600 mg
        - Moderate pain: Ibuprofen 400 – 600 mg + Acetaminophen 325 mg
        - Severe pain: Ibuprofen 400 – 600 mg + Acetaminophen 300 mg & Hydrocodone 7.5 mg
    - Aspirin-like drugs contraindicate:
        - Mild pain: Acetaminophen 325 mg
        - Moderate pain: Acetaminophen 650 mg
        - Severe pain: Acetaminophen 325 mg & Oxycodone 10 mg

- **Oral-Hygiene:** The bacterial content of the sulcus should also be controlled during the healing phase. In addition to stressing to the patient the need for adequate oral hygiene (use a soft toothbrush), the use of chlorhexidine rinses (0.12%) twice a day for 7—10 days is helpful.

- **Lifestyle:** Soft diet.

Follow-up

- **Second Visit (1—2 weeks later)**: The focus is to prevent/eliminate any potential irritants from the root canal space. At this appointment, the splint is removed. Tooth might still have class I or class II mobility after removal, but all indications are that it will continue to heal better without the splint.

Endodontic Treatment			
Extraoral Dry Time Less Than 60 Minutes: Closed Apex	Extraoral Dry Time Less Than 60 Minutes: Open Apex	Extraoral Dry Time More Than 60 Minutes: Closed Apex	Extraoral Dry Time More Than 60 Minutes: Open Apex
Canal is **obturated** when reestablishment of a lamina dura is seen radiographically. However, filling at this visit is acceptable if thorough examination confirms normality. If endodontic treatment is delayed or signs of resorption are present, provide **long term $Ca(OH)_2$** treatment before obturation.	Avoid endodontic treatment and look for signs of revascularization. At the first sign of an infected pulp, initiate **apexification** procedure. Patients are recalled every 3—4 weeks for pulp vitality testing. Thermal tests with carbon dioxide snow or dichloro-difluoromethane are the best methods in these cases.	Teeth with closed apices are treated endodontically in the same was as teeth that had an extraoral time of less than 60 minutes. Endodontic treatment could have been performed aseptically extraorally before replantation.	If **apexification** was not performed out of the mouth, initiate apexification procedure.

    - Coronal leakage caused by defective temporary and permanent restorations results in a clinically relevant amount of bacterial contamination of the root canal after filling. Therefore, the tooth should receive a permanent restoration as soon as possible.
- **3 Months, 6 Months and yearly for atleast 5 years:** If osseous replacement is identified, a more closely monitored follow-up schedule is indicated. In the case of inflammatory root resorption, a new attempt at disinfection of the root canal space by standard retreatment might reverse the process. Teeth adjacent and surrounding the avulsed tooth may show pathologic changes **long after** the initial accident. So, these teeth should be tested at follow-up visits and results compared to those soon after accident.

Management of Traumatic Injuries in Primary Dentition

Crown Fractures without Pulp Exposure	Restore with GIC or composite, or the fracture sites may be smoothed without restoration.
Crown Fractures with Pulp Exposure	Partial pulpotomy with $Ca(OH)_2$, pulpotomy or extraction, depending on the patient's age and cooperation
Crown Root Fracture	**Extraction** is indicated
Root Fracture	Remove coronal part, leave apical part or no treatment if there is no mobility or no marked displacement
Intrusion	Main concern is the effect on the **underlying permanent dentition**, which is estimated at 50%--70% damage rate. If the primary tooth **intruded into** the developing **tooth germ**, **extraction is indicated**. **Otherwise** the tooth may be allowed to **re-erupt spontaneously**. Direction of the apex can be determined by: 1. Inclination of the crown 2. Palpation of the soft tissue above the affected tooth 3. Imaging with periapical/occlusal radiographs. Determine whether the root is forced in palatal or buccal: - **Foreshortened appearance of intruded tooth**: buccal displacement of the root (away from tooth germ) - **Elongated image**: palatal displacement towards permanent successor.
Extrusion	Might be left untreated, repositioned if there is occlusal interference or extracted if there is severe displacement and considerable mobility.
Lateral Luxation	Palatal Displacement of the Crown: leave it **untreated** if there is no occlusal interference. Minor occlusal interference: **slight grinding** Major interference: **reposition** Buccal Displacement of the Crown: In case of collision with permanent tooth bud, **extraction**.
Avulsion	- Ask the parents to bring the avulsed tooth. A **radiographic examination** is essential to ensure that the missing tooth is not intruded. Replantation is **CONTRAINDICATED** as pulp necrosis is a frequent complication. Moreover, there is a risk of further injury to the permanent tooth germ by replantation procedure, whereby the coagulum from the socket can be forced into the follicle.