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**DENTAL TRAUMATOLOGY**

# Traumatic intrusion of permanent teeth. Part 1. An epidemiological study of 216 intruded permanent teeth

Andreasen JO, Bakland LK, Matras RC, Andreasen FM. Traumatic intrusion of permanent teeth. Part 1. An epidemiological study of 216 intruded permanent teeth. © Blackwell Munksgaard, 2006.

Abstract – An epidemiological study of traumatic intrusion of permanent teeth was performed on 216 teeth in 151 patients treated over a 50-year period at a major trauma center in Denmark (Copenhagen). This analysis showed that intrusion of permanent teeth was of rare injury only affecting 1.9% of traumatic injuries involving permanent teeth. The main etiologic factor appeared to be falling which resulted in axial impacts on maxillary or mandibular teeth. The most common injury patterns were intrusion without additional injuries (33.5%) and intrusion with crown fractures (60.5%). A few cases were combinations of intrusion and either crown/root-fractures or root fractures (6%). Most often one tooth was intruded (46.3%), followed by two teeth (32.4% ) and three or more teeth (21.3%). The majority of intruded teeth were displaced 2–8 mm. The age group of 6–12 years of age was most frequently involved and boys appeared to experience intrusion injuries more frequently than girls, and at an earlier age. Maxillary central and lateral incisors are the primary victims of intrusions and this seems to be identical to other trauma types and is possibly related to the known exposure to impacts of maxillary incisors. The reliability of clinical findings, such as lack of mobility (81.8%), metallic percussion tone (72.5%), and no pain to percussion (66%) was reasonably high, whereas a radiographic feature such as the obliteration of the periodontal ligament space appeared to be only a partly reliable diagnostic tool (52%).

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Key words: dental trauma; intrusive luxation; permanent dentition; clinical findings; radiographic findings; treatment strategy; epidemiology

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Intrusion of permanent teeth is a rare dental injury. By definition, an intrusion is an axial displacement of the tooth into the alveolar socket (1). Based on the pathogenesis of this type of injury, the impact has to come in an axial direction (1). One may envision that the impact hits the incisal edge and thus the force drives the tooth in an axial direction. In case of strict axial dislocation the result will be that the tooth will be displaced axially. If the force is in an axial-labial or an axial-lingual direction, the tooth may be displaced in apical-labial or apical-lingual directions. The former displacement results in a labial bone plate fracture.

The rare occurrence of intrusion of permanent teeth has resulted in a minimal amount of data documenting the epidemiological information and clinical radiographic appearance of this type of injury (1). Furthermore, very few clinical reports have been published to document the prognosis ofthese injuries as well as the effect of treatment. (2–10).

In the present study, based on a long-term analysis of traumatic dental injuries treated at a major center, the purpose was to analyze the following aspects of traumatic intrusion of permanent teeth:

1 What is the frequency of intrusion among permanent teeth compared with other dental injuries?
2 What is the main etiological factor for these injuries?
3 What is the typical injury pattern (single or multiple intrusions)?
4 Which other injuries are associated with intrusions (crown fractures, crown/root or root fractures)?
5 What is the age and sex distribution of intrusion injuries?
6 How reliable are clinical and radiographic variables used to diagnose intrusive luxation?

In subsequent articles the outcome of treatment of these injuries will be reported.

## Material and methods

The source of material comprised patients treated for intrusion of permanent teeth at the trauma service at the University Hospital in Copenhagen. Altogether 151 patients with 216 intruded teeth were treated in the period from 1955 to 2003. Among those, 76 teeth in 55 patients had to be eliminated for various reasons in the subsequent studies (Table 1). Teeth diagnosed as intruded in the period from 1955 to 1971 were not treated according to a definite protocol. Teeth treated after 1971 have been presented in an earlier study and treated according to a trauma protocol (8).

### Clinical documentation

At the time of injury, the following parameters were registered on special trauma charts (8, 11): the patient's sex and age, cause of injury, the date and time of injury (hour and minute), number of injured teeth and condition of the supporting tissues.

Table 1. Teeth eliminated from subsequent follow-up studies

| Cause of elimination | Teeth | Patients |
|---|---|---|
| Emergency treatment only | 32 | 23 |
| Tooth extracted at time of injury | 15 | 9 |
| Previous injury with existing pulp pathosis at time of injury | 6 | 4 |
| Pulp canal obliteration | 8 | 7 |
| Associated root or crown-root fracture | 6 | 6 |
| Extensive caries of the intruded teeth | 2 | 1 |
| Patient record incomplete | 7 | 5 |
| Total | 76 | 55 |

*Gingival damage* was recorded as laceration, contusion, or tissue loss. *Bony damage* was recorded as contusion of alveolar socket bone (central intrusion), fracture of labial bone plate, or fracture of the alveolar process as a whole. *Fracture of hard dental tissues* was recorded as crown infractions, enamel fractures, enamel-dentin fractures with and without pulp exposure, crown-root fractures with and without pulp exposure, and root fractures.

For each tooth, objective clinical information from the time of injury and follow-up examinations were recorded on a standardized form, which included: tooth color (i.e. normal, yellow, red, grey or restored with crown), dislocation (mm; in vertical and horizontal direction), loosening (on scale from 0 to 3, where 0 indicated no abnormal loosening; 1, facio-lingual and/or mesio-distal movements of not more than 1 mm; 2, facio-lingual and/or mesio-distal movement of more than 1 mm; 3, vertical/axial mobility), tenderness to percussion, and percussion tone (normal or an ankylosis tone). A high, metallic percussion tone was registered when an injured tooth was locked into bone.

At follow-up examinations, a high percussion tone indicated ankylosis (11). Electrometric sensibility was also registered. Sensibility was measured on a scale of 0–4 with intervals of one-half with a Siemens Sirotest® Pulp Tester (Siemens AG, Erlangen, West Germany), according to established procedures (11). Electrometric pulp testing was always performed on the incisal edge, as this location was found to give the lowest threshold value (11). Injured and adjacent non-injured (control) teeth were tested at the time of injury and at all subsequent follow-up controls. In a previous study, it was found that reproducible pulp tests could be carried out in the presence of various splints or temporary crowns provided that the necessary precautions were taken (e.g. isolation of the teeth with orthodontic bands with acetate strips prior to the pulp testing) (12).

At follow-up examinations, the above-mentioned registrations were supplemented with the following: the presence or absence of fistulous tracts, gingivitis, gingival dehiscence, and gingival pocket depth (11).

### Photographic documentation

Horizontal and axial photographs of the injuries were taken routinely for all patients from 1972.

### Radiographic documentation

The following injury factors were registered. *The extent of intrusion* measured to the nearest millimeter with a sliding caliper on the most reliable radiograph (usually the bisecting angle exposure) (11).

*Stage of root development* was classified into the following stages: 1, one-quarter root formation; 2, one-half root formation; 3, three-quarters root formation; 4, full root formation, open apex; 5, full root formation, half-closed apex; 6, full root formation, apex closed (8).

### Treatment

After determining the diagnosis and the extent of injury, one of three treatment options were chosen in a non-randomized pattern.

1. *Expected spontaneous re-eruption.* This plan was followed when re-eruption was expected to take place and was verified at subsequent clinical and radiographic controls. This treatment modality was usually chosen in case of teeth with immature formation, but in a few cases also for teeth with completed root formation. The progression of re-eruption was followed at 1- or 2-month intervals.
2. *Surgical repositioning.* In these cases, local anesthesia was applied and forceps were used to reposition the tooth either partially or totally. If necessary, proximal sutures were placed to adapt the gingival tissues around cervical area of the root of the tooth, after which a splint was applied and maintained until a radiograph showed satisfactory socket healing. A variety of splints were used such as **rigid** splints (capsplints made of silver or acrylic), **semirigid** (acid-etch composite splints, orthodontic bands united with acrylic or arch bars and arch bars fastened with 0.3 mm soft steel wires) and **flexible**, i.e. acid-etch splints using a flexible resin (Protemp®, 3 M, ESPE Dental Products, St. Paul, MN, USA) (1).
3. *Orthodontic extrusion.* In these cases, the teeth were repositioned using orthodontic forces. The orthodontic treatment procedures have previously been described (1). The orthodontic appliances were usually placed after a few days because of bleeding and swelling initially. The intention was usually to reposition the teeth over a period of 4–6 weeks, but many cases required several months time. After the teeth had reached their normal levels, the appliances were often maintained for some extra weeks in order to secure stabilization of the teeth during the extensive alveolar remodeling.
4. *Splinting period.* The splinting period was in most cases 6–8 weeks and was, in most cases, determined by the radiographic appearance of bone healing and reformation of a periodontal ligament space (1).
5. *Antibiotic treatment* was normally administered, usually penicillin in doses of 1 gm immediately and 500 mg four times daily for 4 days.

### Follow-up strategy

Since 1966, patients were followed at regular intervals, e.g. 3, 4, 6, 8 weeks, 6 months and then annually up to 5 years. A few patients were monitored up to 10 years after injury or longer. At each follow-up control, a clinical and radiographic examination was carried out, using standardized forms for clinical data as well as standardized radiographs and clinical photographs. These techniques have been described in detail in a previous publication (11).

### Diagnosis of periodontal healing and complications

*Periodontal healing.* A previous clinical study has shown that periodontal healing after luxation injuries can be divided into the following groups (11).

*Normal periodontal healing*, if the mobility of the injured tooth is equal to that of the control tooth, and there are no radiographic signs of root resorption.

*External resorption (repair related resorption)*, if there is a radiographic defect on the root surface that is bordered by a normal periodontal ligament (PDL) space and lamina dura.

*Inflammatory resorption (infection related resorption)*, if there is radiographic sign of external resorption cavities affecting both the root surface and adjacent bone. Mobility values are high until arrest of the inflammatory progress by interceptive endodontic therapy.

*Permanent replacement resorption (ankylosis related resorption)*, if there is loss of the PDL space. Moreover, a high metallic percussion sound can be elicited as well as no or decreased mobility values.

*Transient replacement resorption*, if there is lowered mobility which later becomes normal.

*Periodontal healing* was evaluated clinically by probing the gingival sulcus at the follow-up visits. It should be noted that periodontal probing was *never* performed at the time of injury. The deepest site was registered. Values >3 mm were considered pathologic. The level of the alveolar crest was assessed radiographically. Periodontal status was considered normal if the distance between the cemento-enamel junction and the alveolar crest was not >2 mm on a bisecting angle radiograph. A greater distance was registered as pathological and considered as loss of marginal attachment.

*Loss of marginal bone.* The extent of bone destruction was determined radiographically from radiographs taken with a bisecting angle technique. The bone loss was measured with a sliding caliper to the nearest mm. mesially and distally and the deepest of those measures used as reference.

*Root development.* If the intruded tooth had incomplete root formation at the time of injury, the following events were considered. Continued root development, if the root of the intruded tooth achieved the same length and form as a contralateral non-injured tooth; disturbed root development, if a deformed an usually shorter root developed; arrested root development, if development failed to continue after at the time of injury (11).

*Pulp necrosis*, if there was grey crown discoloration combined with periapical radiolucency and/or inflammatory resorption. Sensibility testing was also considered; but a negative response was not considered pathognomonic for pulp necrosis. Following intrusion of teeth with completed root formation, the pulp was extirpated prophylactically, as pulpal revascularization was not anticipated (1).

When pulp necrosis was diagnosed, the pulp was extirpated and calcium hydroxide (Calasept®, Scania Dental, Knivsta, Sweden) was placed in the root canal. In mature teeth, a gutta-percha root filling was inserted 4–6 months later. In teeth with immature root formation, apexification was initiated before definitive root filling with gutta-percha and sealer was completed (1).

## Results

### Frequency of intrusion of permanent teeth

This parameter was examined in the period from 1972 to 1982, when most of oral trauma cases in the city of Copenhagen were treated at the University Hospital in Copenhagen. It appears that 87 intrusions constituted 1.9% of 4525 traumatized permanent teeth treated in 1972–82 and throughout this period, this frequency was very stable.

### Etiology of intrusion

It appears from Table 2 that a direct fall against a hard object, such as the ground, was the most common cause followed by bike injuries. The impact direction could only be verified in a few patients but it appeared from these cases to be axial or close to axial of the involved anterior teeth.

Table 2. Causes of injury

| Causes | *n* |
|---|---|
| Falling while running/playing | 49 |
| Bicycle accidents | 29 |
| Victim of a car or motorcycle accidents | 12 |
| Sports activities | 10 |
| Fights | 10 |
| Falling from heights | 5 |
| Hit by a tool | 4 |
| Collision with another person | 1 |

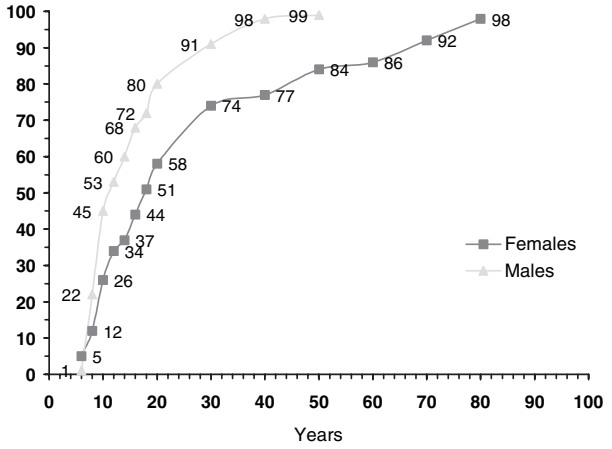


*Fig. 1.* Cumulative frequency of intrusions in males and females.

### Age and sex

It appears from Fig. 1 that the 6–12 year old age group was most frequently involved in intrusion injuries, but it also occurred later in life. Boys appear to suffer intrusion earlier than girls do (Fig. 1). There appears to be a difference in the sex proportion of intrusion with males being slightly more frequently exposed to intrusion. Altogether 78 males had 123 intruded teeth, whereas 62 females suffered 93 intrusions.

### Injury pattern (simple or multiple intrusions)

The injury pattern ranged from one to five teeth (Table 3). Most of the patients had one tooth intruded; the next most common was two intruded teeth.

### Location of intrusions

Table 4 shows that the maxillary central and lateral incisor constituted the majority of cases and that mandibular teeth were seldom involved.

### Extent of intrusions

The extent of intrusion ranged from 1 to 20 mm, with most of the intrusions being within 1 to 8 mm (full crown length) (Table 5).

Table 3. Number of intruded teeth

| Number of intruded teeth | Frequency | Percent |
|---|---|---|
| 1 | 100 | 46.3 |
| 2 | 70 | 32.4 |
| 3 | 28 | 13.0 |
| 4 | 13 | 6.0 |
| 5 | 5 | 2.3 |
| Total | 216 | 100 |

Table 4. Tooth location

| Tooth location | Frequency | Percent |
|---|---|---|
| Maxillary central incisors | 148 | 68.5 |
| Maxillary lateral incisors | 48 | 22.2 |
| Maxillary canines | 14 | 6.5 |
| Maxillary premolars | 2 | 1.0 |
| Mandibular incisors | 3 | 1.4 |
| Mandibular premolars | 1 | 0.4 |

Table 5. Extent of intrusion (mm)

| Intrusion (mm) | Frequency | Percent |
|---|---|---|
| 1 | 1 | 0.5 |
| 2 | 19 | 9.1 |
| 3 | 23 | 11.0 |
| 4 | 37 | 17.7 |
| 5 | 42 | 20.1 |
| 6 | 15 | 7.2 |
| 7 | 16 | 7.7 |
| 8 | 21 | 10.0 |
| 9 | 8 | 3.8 |
| 10 | 16 | 7.7 |
| 11–20 | 11 | 5.4 |
| Unknown | 7 | |

### Additional injuries to intrusive luxations

Crown fractures (enamel and enamel-dentin) were frequently associated with intrusions (16.6% and 41.7%), but no fractures were also a frequent finding (32.7%) (Table 6).

### Clinical parameters

It appears from Tables 7 and 8, that the clinical parameters mobility and percussion response, and percussion sound (Table 9) were not strongly related to the diagnosis intrusive luxation; the percussion test was positive in 72.5%.

Table 6. Associated crown fractures, crown-root or root fractures

| Fracture | Frequency | Percent |
|---|---|---|
| None | 69 | 32.7 |
| Infraction | 3 | 1.4 |
| Enamel | 35 | 16.6 |
| Enamel-dentin | 88 | 41.7 |
| Enamel-dentin and pulp exposure | 7 | 3.3 |
| Crown-root | 6 | 2.8 |
| Root fracture | 3 | 1.4 |
| Unknown | 5 | |

Table 7. Grade of mobility (0–3)

| Mobility | Frequency | Percent |
|---|---|---|
| 0 | 117 | 81.8 |
| 1 | 8 | 5.6 |
| 2 | 2 | 1.3 |
| 3 | 16 | 11.2 |
| Unknown | 73 | |

Table 8. Percussion response

| Percussion sensibility | Frequency | Percent |
|---|---|---|
| 0 | 76 | 66.0 |
| 1 | 39 | 34.0 |
| Unknown | 101 | 100 |

0, no pain; 1, discomfort.

Table 9. Percussion sound

| Percussion sound | Frequency | Percent |
|---|---|---|
| Normal | 14 | 27.5 |
| Metallic | 51 | 72.5 |
| Unknown | 165 | |

Table 10. Radiographic signs of intrusion

| X-ray PDL sign | Frequency | Percent |
|---|---|---|
| 0 | 97 | 48.2 |
| 1 | 104 | 51.8 |
| Unknown | 15 | |

0, normal; 1, obliterated (either totally or in places).

### Radiographic parameters

Evaluation of the radiographs taken immediately after the injury showed that obliteration of the periodontal ligament space was found in 51.8% of the cases (Table 10; Fig. 2). An important finding was that the level of the enamel-cementum junction in erupted teeth was a good parameter to evaluate for the extent of intrusion (Fig. 3). Furthermore, a lateral radiograph in the case of a non-axial displacement could reveal that an apparent shortening of the tooth shown on conventionally radiograph represents a displacement through the labial bone plate (Fig. 4). By contrast, the appearance of 'lengthening' of a tooth would appear to represent a displacement in palatal direction. Finally a periapical exposure showed more optimally than anocclusal exposure the extent of dislocation (Fig. 5).

## Discussion

The 1.9% frequency of intrusions among injured permanent teeth is a little higher that other studies showing frequencies ranging 0.3–0.5% (13–16), a finding possibly related to the fact that the figure 1.9% originates from a trauma center to which more severe injuries are frequently referred. The low incidence may explain the paucity of knowledge about treatment of these injuries (1).

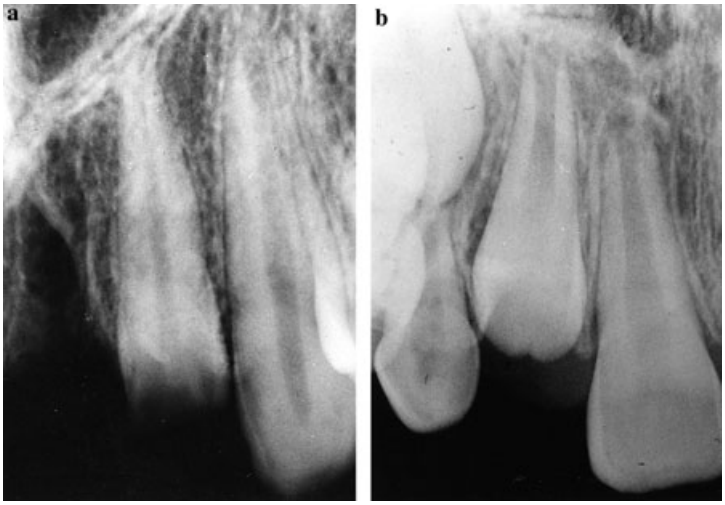


*Fig. 2.* (a) Intrusive luxation of lateral incisor. Note disappearance of the periodontal space around the displaced tooth. (b) Intruded lateral incisor. Note that a periodontal space is present along most of the root surface.

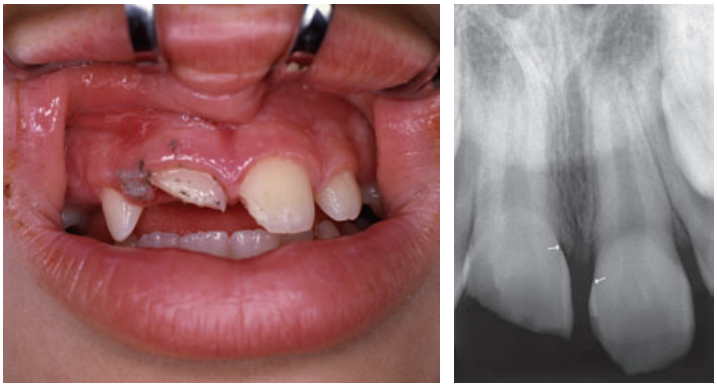

*Fig. 3.* Intrusion of central incisor with complete root formation. Note the difference in position of the cemento-enamel junction compared with the adjacent incisor (arrows).

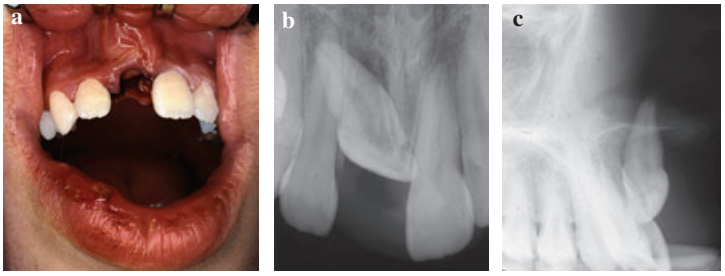


*Fig. 4.* Radiographically foreshortened intruded central incisor appears on a lateral exposure to be displaced through the labial bone plate. (a) Photograph showing intrusion of maxillary right central incisor. (b) Periapical film shows the tooth to be shorter than the left central incisor. (c) Lateral jaw film shows labial intrusion of the tooth.

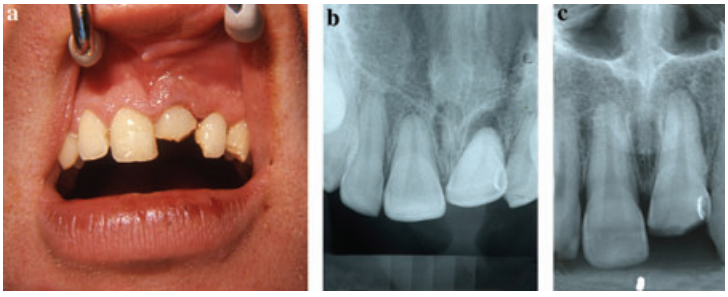


*Fig. 5.* A more steep exposure i.e. an occlusal exposure, does not give a reliable impression of the depth of the intrusion compared with a periapical bisecting angle exposure. (a) Photograph of intruded maxillary left central incisor. (b) Occlusal exposure fails to reveal extent of intrusion. (c) Periapical film more accurately shows the extent of the intrusion.

The etiology of intrusions apparently differ from country to country; thus in Austria waterslides was the dominating cause (6), whereas this was not the case in Denmark, where common falls was the dominant etiology followed by bicycle injuries.

Because the nature of most dental injuries are the result of direct, frontal impacts (falls), most injuries in the permanent dentition are crown and crown – root fractures with only occasional luxations. In the present study, we found that axial impact forces resulted in crown fractures and intrusions of the teeth. Crown fractures associated with intrusions may be of importance in treatment and prognosis. The exposed dentin may allow bacterial invasion and subsequent development of pulp necrosis (17–19). In order to prevent such a situation a bacteria tight coverage of exposed dentin is recommended. The influences of such procedure will be discussed in a subsequent report.

The frequent occurrence of multiple intrusions possibly reflects the nature of the trauma situation being an axial impact where naturally several teeth can become involved. This phenomenon has a significant influence upon prognosis as two teeth with adjacent injured periodontal ligament do have a more severe healing problem (10). This topic will be further discussed in a subsequent report.

Generally, age and sex distribution reflects the trauma exposure of a population with boys being more exposed than are girls. The ratio found in this study is within the ranges of all dental traumas of permanent teeth. The general earlier appearance of intrusions in boys compared with girls, may lead to a difference in healing, as healing is very much dependent upon root development. This factor will be discussed in a subsequent study.

The preference for intrusion to the maxillary central and lateral incisor appears to be related to the common fall direction in which these teeth are generally the first to make contact with extraoral objects. The reliability of clinical and radiographic features appears to be rather limited. However, a high metallic percussion sound, when found, is of diagnostic importance. It might be expected that radiographic examination of an intruded tooth should reveal obliteration of the periodontal ligament space. However, this only occurred in half of the cases. It is not clear why this is so. With regard to making diagnosis of intrusion, the position of enamel-cementum junction in relation to neighboring teeth may be of diagnostic importance in cases with fully erupted teeth.

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