Case Report

Development of ankylosis in permanent incisors following delayed replantation and severe intrusion

Campbell KM, Casas MJ, Kenny DJ. Development of ankylosis in permanent incisors following delayed replantation and severe intrusion.

Abstract – Ankylosis is a predictable outcome for replanted incisors and for most severely intruded incisors. There is no treatment to arrest or reverse this periodontal ligament complication. Ankylosis of the incisors of preadolescents alters local alveolar growth and eventually produces tooth loss subsequent to resorption. Currently, clinical methods used to diagnose ankylosis in the early postinjury period include subjective assessments of percussion sound and mobility and quantitative devices such as the Periotest®. This paper describes the progression of ankylosis in two preadolescent patients that sustained severe trauma to their maxillary central incisors. A number of clinical assessments for diagnosis of ankylosis were compared for their usefulness, reliability and suitability.

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Ankylosis of tooth root to alveolar bone is the most commonly reported periodontal ligament (PDL) complication following replantation (1). It has also been shown to develop in approximately 70% of incisors that had been intruded greater than one-half of the clinical crown (2). Despite considerable knowledge about the pathogenesis of ankylosis from animal studies and observation of human replanted teeth, there is no known treatment to arrest this complication or change its outcome of eventual tooth loss.

Clinical detection of ankylosis is based on subjective appraisals of mobility and percussion sound. The reliability of the Miller index (3), which assigns numeric values to tooth mobility, is debatable due to variability in experience of the clinician and their interpretation of the index values. A device designed to assess mobility, the Periotest® (Siemens/Medizintechnik, Bensheim, Germany), has been described as an objective method for diagnosis of ankylosis (4) but its suitability for use in dental traumatology is questionable (5, 6). Detecting a characteristic sound from a tooth by percussion with a dental mirror handle has been shown to be reliable for the diagnosis of ankylosis. This test demonstrates both high sensitivity and specificity when used by experienced clinicians (7). Observation of progressive infraocclusion and the detection of replacement resorption by radiographic interpretation are late diagnostic signs of ankylosis.

Two case reports will illustrate the development of ankylosis in preadolescents following different severe luxation injuries.

Case reports

Two patients were followed in the Dental Department at The Hospital for Sick Children, Toronto, Canada. Data collection was completed at trauma follow-up visits for the patient described in Case 1. The patient described in Case 2 wished to attend his community-based dentist's office for continuing care

but returned to the department for periodic data collection visits. All data collection was completed with the patient semi-reclined in the dental chair. After an initial cursory clinical examination, a standard set of photographs of the maxillary anterior segment was taken. The Miller index and a subjective assessment of percussion sound were documented for all maxillary incisors present including non-injured adjacent incisors. Five consecutive Periotest® values (PTVs) were recorded for each incisor and the mean PTV calculated. Radiographic examination was performed as required for follow up.

Case 1

A 10.8-year-old male was referred following delayed replantation of both avulsed maxillary central incisors. Teeth 11 and 21 were avulsed in a fall on the ice in the school playground. A community-based dentist replanted and splinted the incisors after an extraoral time of approximately 180 min. It was not reported whether antibiotics were prescribed.

On initial presentation 8 days after replantation, the maxillary incisors were stable with a light orthodontic wire/composite resin splint in place. Pulpectomies were performed under local anesthesia and calcium hydroxide dressing was placed in the canals of both incisors. The splint was removed 2 weeks later. The incisors were assessed at 2, 4, 16, 27, and 57 weeks (Table 1). The patient refused PTV readings at the 2- and 4-week appointments and permitted only one reading for each of the injured teeth. The patient explained that he disliked assessment with the Periotest® despite introduction with 'tell-show-do' prior to use. Final endodontic treatment of 11 and 21 was completed at 16 weeks postinjury and ankylosis was confirmed by lack of mobility and characteristic percussion sound (Fig. 1).

Table 1. Summary of longitudinal data for Patient 1

	Tooth No.											
	Miller index				Mean PTV				Percussion sound			
Weeks post-trauma	12	11	21	22	12	11	21	22	12	11	21	22
2	1	2	2	1	NR	38.0	32.0	NR	N	N	N	N
4	1	2	1	1	NR	23.0	28.0	NR	N	N	N	N
16	1	0	0	1	12.6	6.2	5.4	11.2	N	Y	Y	N
27	1	0	0	1	9.6	4.6	2.2	10.4	N	Y	Y	N
57	1	0	0	1	11.0	3.6	2.8	12.2	N	Y	Y	N

The shaded columns represent the replanted teeth that were being followed for the development of ankylosis.
Y, ankylosed; N, non-ankylosed; PTV, Periotest® value; NR, no reading; patient refused.

Fig. 1. Clinical appearance of patient 1 at 16 weeks following replantation of 11 and 21. Ankylosis was confirmed in both central incisors by characteristic percussion sound and lack of mobility.

Radiographic evidence of replacement resorption affecting both teeth was noted at the 57-week assessment and consultation with a staff oral surgeon was completed at that time (Fig. 2). Despite minimal evidence of infraocclusion (Fig. 3), it was recom-

Fig. 2. Radiographic appearance of patient 1 at 57 weeks postinjury. Note the lack of PDL space and replacement resorption especially in the apical 1/2 of 21.

Fig. 3. Clinical appearance of patient 1 at 57 weeks postinjury. The esthetic effects of infraocclusion are minimal.

mended that 11 and 21 be extracted within 6 months. In further consultation with the staff prosthodontist, oral surgeon and the patient's mother, it was decided to postpone the extractions indefinitely and maintain the ankylosed teeth *in situ*. The rationale for this decision was related to the dental development of the patient, the number of transitional partial dentures that would be required until a definitive restoration could be placed and to date, the negligible effect on facial esthetics produced by minimal infraocclusion.

Case 2

A 12.3-year-old male presented following severe intrusion of his maxillary central incisors. This injury was the result of collision with a goal post during soccer. On presentation, both incisors were intruded nearly the full crown length (>10 mm) and so surgical repositioning under local anesthesia was undertaken. Stabilization was achieved with light orthodontic wire/composite resin splint and interproximal soft tissue sutures. A 7-day course of antibiotics was prescribed. Ten days postinjury, pulpectomies with intracanal calcium hydroxide dressing were performed on 11 and 21 by an endodontist. The splint was also removed at that visit. The first data was collected at week 5, followed by data collection at weeks 9, 15, 23, and 42 (Table 2). At week 9, clinical signs of ankylosis were noted in both central incisors based on lack of mobility and percussion sound (Fig. 4). By week 42 very early radiographic evidence of replacement resorption was detected but minimal clinical evidence of infraocclusion noted (Figs 5 and 6). At 42 weeks, gutta percha obturation of the affected incisors had not been completed by the endodontist who stated that he intended 'to obturate the teeth '11' and '21' once a normal PDL has been established (in approximately 3 months to 1 year).'

Table 2. Summary of longitudinal data for Patient 2

	Tooth No.											
	Miller index				Mean PTV				Percussion sound			
Weeks post-trauma	12	11	21	22	12	11	21	22	12	11	21	22
5	1	2	1	1	10.2	20.4	10.8	16.8	N	N	N	N
9	1	0	0	1	13.4	6.8	6.0	10.6	N	Y	Y	N
15	1	0	0	1	9.4	6.2	5.4	7.2	N	Y	Y	N
23	1	0	0	1	9.4	5.4	5.8	9.2	N	Y	Y	N
42	0	0	0	0	6.6	6.8	5.8	6.2	Y	Y	Y	Y

The shaded columns represent the severely intruded teeth that were followed for the development of ankylosis.
PTV, Periotest® value; Y, ankylosed; N, non-ankylosed.

Fig. 4. Clinical appearance of patient 2 at 9 weeks following severe intrusion of 11 and 21. Ankylosis was confirmed in both central incisors by characteristic percussion sound and lack of mobility.

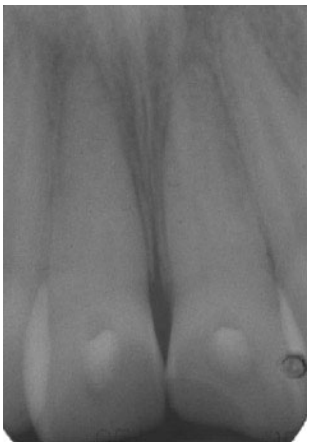

Fig. 5. Radiographic appearance of patient 2 at 42 weeks postinjury. Replacement resorption minimally evident in both 11 and 21. Calcium hydroxide dressings remain in both canals.

Fig. 6. Clinical appearance of patient 2 at 42 weeks postinjury. The esthetic effects of infraocclusion are minimal.

Discussion

These cases illustrate that ankylosis can be expected subsequent to both delayed replantation and severe

intrusion. Severe intrusion and undue delay in the replantation of an avulsed incisor (beyond 5 min) (1) create irreparable damage to the PDL. It is known from animal and *in vitro* studies (8–11) that the effects of mechanical injury, desiccation and inflammatory-mediated processes, combined or alone, compromise the PDL at the cellular level. Necrosis of large areas of the PDL produces an overall deficiency of functional progenitor cells, fibroblasts and cementoblasts. This deficit permits preferential repopulation of the defect by endosteal cells from the adjacent bone marrow spaces (12–14). These cells, capable only of osteogenesis and osteoclasis, initiate ankylosis and replacement resorption.

Development of ankylosis was predictable on the basis of the nature and severity of these injuries. Once patient 1 was assessed 8 days postreplantation, all risks were fully disclosed but it was decided to maintain the teeth *in situ*. Patient 2 and his mother agreed to proceed with treatment from the outset, despite having been informed of all risks, including tooth loss subsequent to ankylosis.

Both patients demonstrated clinical signs of ankylosis (lack of mobility and characteristic 'high' percussion sound) within weeks of the initial injury. It has been demonstrated that when approximately 20% of the tooth root is affected, ankylosis can be detected by these clinical features (15). Assessment of the percussion sound of maxillary incisors has recently been shown to be a reliable diagnostic test for ankylosis (7). These cases serve to strengthen the evidence that a characteristic percussion sound is diagnostic for ankylosis even in its early stages.

The Periotest® is a device that provides a quantitative value for tooth mobility. The 'PTV' or PTV ranges from −8 to +50, with lower PTV indicating less mobility. This instrument was initially designed to assess outcomes of periodontal therapy and later was used for assessment of implant osseointegration. Due to the wide variation in physiologic PTV for preadolescents (5–7, 16) dependence on a low PTV to diagnose ankylosis is unreliable. Similarly, the Miller index, an ordinal scale used to describe the mobility of teeth (3), was originally developed to quantify the extent of periodontal disease. Over the years it has been adopted to document tooth mobility. In this investigation, the Miller index value described the extent of mobility over time but revealed nothing about the actual condition of the tooth. The observed decrease in Miller index values of the incisors corresponded to the downward trend of mean PTV. The mean PTV showed a substantial drop from the previous reading at the time the percussion sound was noted to change in both patients. In general, the difference between the ordinal values of the Miller index corresponded to a wide range of PTV. In fact, the range of mean PTV that represented 'ankylosis' or a Miller index value of '0' ranged from 2.2 to 6.8. Therefore, it is not accurate to differentiate an ankylosed incisor by its specific PTV. The Periotest®, despite its ability to provide measures of tooth mobility in fine increments, adds no more to the diagnosis of ankylosis than confirmation.

These cases illustrated other limitations of the Periotest® for use in dental trauma management. The first limitation is the lack of acceptance by some pre and adolescents for the Periotest® device in the early postinjury period due to discomfort from the firm repetitive tapping. Second, the test-retest reliability was difficult to assess because of the dental development of the patients. One would typically expect a decrease in physiologic PTV with time due to root growth and PDL maturation that occurs with increasing age. Consequently, a decrease in the PTV of a growing child must be interpreted with caution, as it may be physiological.

Early radiographic changes due to replacement resorption are often obscured because of the common labial or lingual location of the initial sites of ankylosis (17). Superimposition of bone marrow trabeculae and other structures may also camouflage areas of root resorption (18). These cases confirm that the reliable diagnosis of replacement resorption by radiographic interpretation occurs much later than its clinical detection.

Ankylosis of permanent incisors creates a localized arrest in the growth of the alveolus. This is of concern in the preadolescent population as the risk of infraocclusion is greater if the patient is diagnosed with ankylosis before the pubertal growth spurt (19, 20). As well, replacement resorption is accelerated by the higher metabolic rate of the actively growing adolescent and decreased root mass in immaturely developed teeth. Ankylosis has the potential to compromise esthetics and function of the developing dentition and complicate restorative care for the patient. Due to the stage of development of these patients it is anticipated that infraocclusion will be noticeable within the next year and proceed due to the onset of the pubertal growth spurt and associated vertical jaw growth. To minimize the negative consequences of infraocclusion it will be necessary to choose management strategies for these patients. Some of the current options (21) include: extraction of the ankylosed incisors with placement of a transitional prosthesis followed by bone grafting and implant placement at skeletal maturity. Decoronation (crown amputation with transitional prosthesis) is performed with the intent to preserve the ridge dimensions prior to implant placement. Alveolar distraction osteogenesis remains if the decision is made not to intervene but

to allow infraocclusion to occur. This procedure involves segmental osteotomy and repositioning the infraoccluded teeth and bone segment using distraction devices. The objective is to enhance ridge dimensions and preclude bone grafting prior to implant placement. In some cases, the infraocclusion can be corrected and the ankylosed teeth can be maintained *in situ* for some time. Unfortunately this technique is unable to arrest replacement resorption, which will continue at the same rate as normal skeletal turnover and eventually the affected teeth will be lost.

Conclusions

The development of ankylosis was demonstrated in two clinical cases that involved maxillary central incisors: one of delayed replantation and one of severe intrusion. The characteristic percussion sound demonstrated by the affected teeth verified the diagnosis of ankylosis within weeks of the initial injury. The miller index provided a limited appraisal of the state of the periodontium until a value of '0' was noted. The Periotest®, although able to confirm the diagnosis of ankylosis in a relative manner, appeared to be of little additional value since the diagnosis had been made reliably by much simpler methods such as assessment of percussion sound. It was also shown that the Periotest® was not well accepted by preadolescents especially in the early postinjury period.

Early radiographic signs of ankylosis/replacement resorption were noted only late in the observation periods for these two patients. Minimal evidence of infraocclusion was observed but these patients, both male, have not reached their pubertal growth period. It is anticipated that infraocclusion will become apparent and then it will be important to minimize any negative growth-related consequences to aid rehabilitation.

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