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Ankylosis of permanent teeth: a case report and literature review

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ABSTRACT: A case report describing an ankylosed permanent maxillary canine which was brought into the arch by a combination of surgery and orthodontics is used as a basis to review the literature concerning many aspects of the management of ankylosed permanent teeth. The literature indicates surgical luxation is a two edged sword, that is, it may cause ankylosis if used with surgical exposures but it can also be the only means of treating ankylosis. The treatment of the canine which is the subject of this case report resulted in damage to the tooth. Vanarsdall's recent# contributions in this field are detailed.

Reference: Aust.Orthod.J.11(1):38-44

MeSH words: ankylosis; periodontal ligament; surgery/oral; tooth eruption; tooth mobility; tooth unerupted
Key words: dental ankylosis, surgical luxation, traction, surgical exposure

CASE HISTORY

The patient, a male born 21/12/66, presented on 19/4/82 with an OPG taken 2 months previously *(Figure 1)*. The diagnosis was made of a Class I tending towards a Class III malocclusion, with a reduced overbite, unerupted palatal 23, teeth missing: 12, 18, 22, 36, 46, and the upper and lower incisors exhibiting attrition. Twelve months earlier, in April 1981, the patient's general dentist had attempted to uncover 13 and 23. Bone was removed and the teeth may have been stimulated. The overall treatment plan in April 1982 was to re-uncover 23, await its eruption, then band both arches, close the maxillary spaces and accept the lower spaces.

The treatment planned by the oral surgeon was to expose, stimulate and pack 23, and this was done on 26/8/82 (no record was made whether 23 was stimulated). After a fortnight the pack was removed and 2mm of the tip of the cusp of 23 was visible. By 17/2/83, 23 had not erupted further so it was bonded and tied to the archwire. Eleven days later the bond came off. The 23 was re-exposed and a defect was noted in the enamel on the distolabial aspect.

In April 1983, 23 was rebonded and traction re-applied. Several further visits for application of traction were necessary and a periapical radiograph was taken on 8/6/83 *(Figure 2)*. By July 1983, 23 still had not moved. The tooth gave a positive response to CO_2, was mobile but produced a different percussion sound compared to the neighbouring teeth. The OPG taken at that time *(Figure 3)* shows how the adjacent teeth were intruding and that an open bite was developing in the region.

On 28/9/83, 23 was surgically mobilised by rotating the tooth 45°. Traction was applied immediately (within 20 minutes) to the tooth and on 20/10/83, 23 had moved but no longer responded to CO_2. A month later 23 was still moving. The distolabial cavity in 23 was restored. At the adjustment visit of 27/2/84 the position of 23 was satisfactory *(Figure 4)*. The patient was debanded on 16/3/84 *(Figure 5)* and a root filling of 23 carried out. At the check visit on 17/7/87 (three years and ten months after surgical mobilisation) 23 was perfectly satisfactory *(Figures 6(a), 6(b)* and *6(c))*.

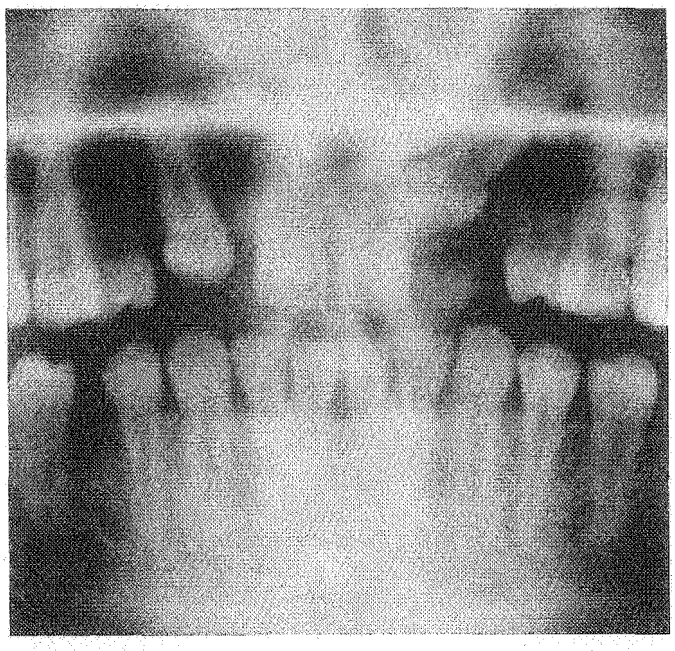

Figure 1. OPG of 17/2/82 (two months before presentation)

LITERATURE REVIEW

Tooth ankylosis is defined by Pindborg (1970) as the fusion of cementum or dentine with alveolar bone. Since deciduous molar teeth comprise the majority of the teeth which are ankylosed (see Biederman (1968) below) it is not surprising that the bulk of the literature is devoted to aspects of the ankylosis of deciduous molar teeth. However this literature review will mainly discuss the ankylosis of permanent teeth.

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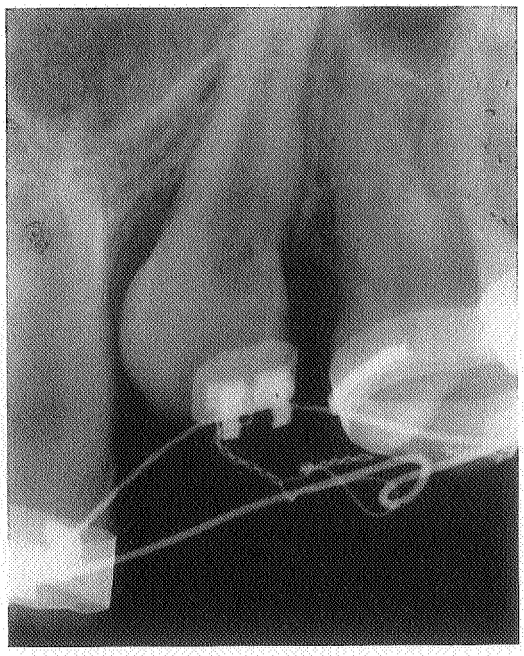

Figure 2. Periapical of 23 taken on 8/6/83

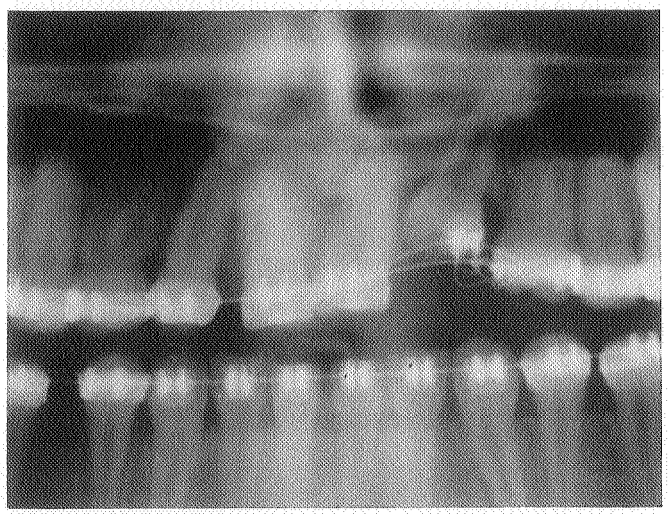

Figure 3. OPG of 21/7/83 showing that 23 has not moved significantly and the adjacent teeth are intruding

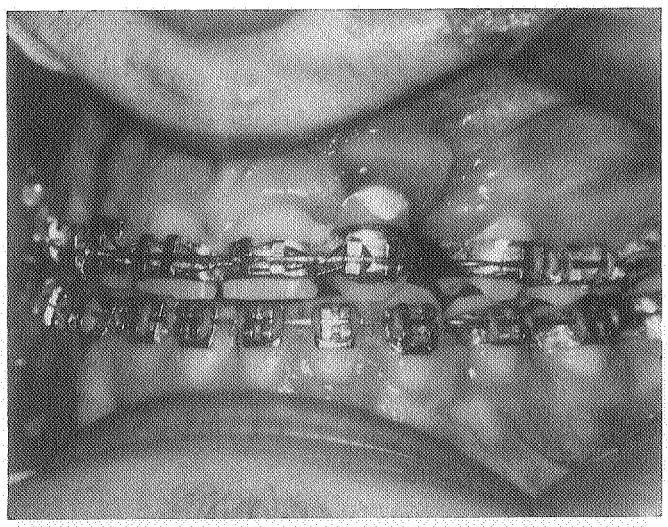

Figure 4. Intra-oral view taken on 27/2/84 showing 23 in a satisfactory position, five months after mobilisation

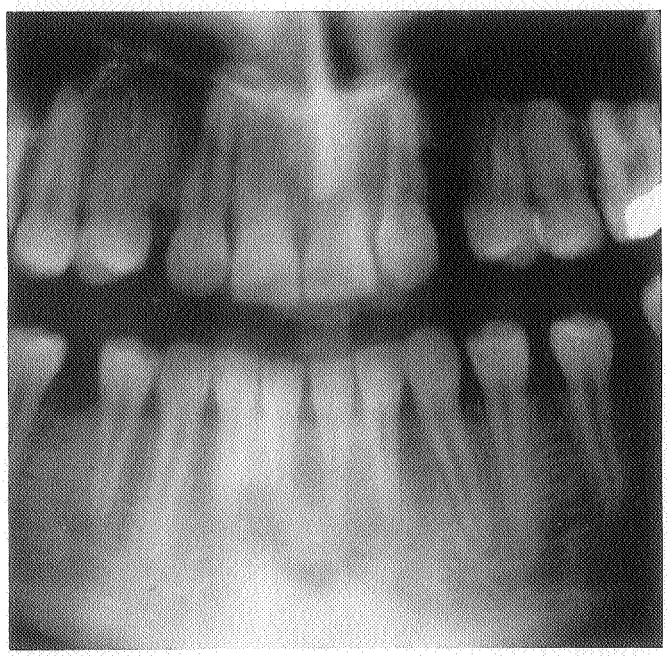

Figure 5. OPG taken at debanding 16/3/84

Biederman (1968) in a comprehensive article discussed the characteristics of ankylosed teeth including aetiology, incidence, diagnosis, clinical appearance and treatment. He found 285 patients with 502 ankylosed teeth. Ninety-one per cent of these teeth were deciduous molars and 9% were other upper and lower teeth. of which the most common was the permanent first molar. He stated that the cause of tooth ankylosis may be:

(a) a genetic or congenital gap in the periodontal membrane
(b) some random or accidental occurrence, including trauma
(c) a disturbed local metabolism.

He presented four ways of managing ankylosed teeth.

1. By immediate extraction, particularly indicated if the ankylosed tooth is deciduous with a permanent successor present.
2. By building up the tooth to restore occlusal and proximal contacts, when ankylosis occurs late and the restoration is performed after maturity.
3. By the use of a luxation technique.

Biederman stated that is was Hemley (1953) who first proposed to correct ankylosis by surgical luxation of the tooth thereby breaking the bony bridge of ankylosis. Biederman said that the tooth should be grasped firmly with dental forceps and rocked bucco-lingually, the axis of the arc of movement being essentially through the apices. The important objective is to break the bony bridge of ankylosis without injuring the apical nutrient vessels. As a result of the consequent inflammation fibrous tissue is formed in the reparative process. This fibrous tissue becomes co-extensive with the periodontal membrane, in effect restoring its continuity and tooth eruption can resume. He stated that the response to this luxation technique may not be immediate and if no change is

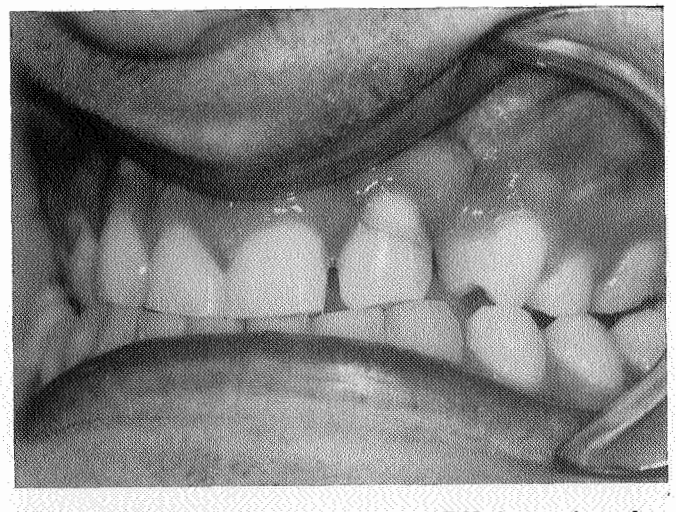

Figure 6(a). Intra-oral view taken of 23 on 17/7/87, 3 years 4 months after debanding

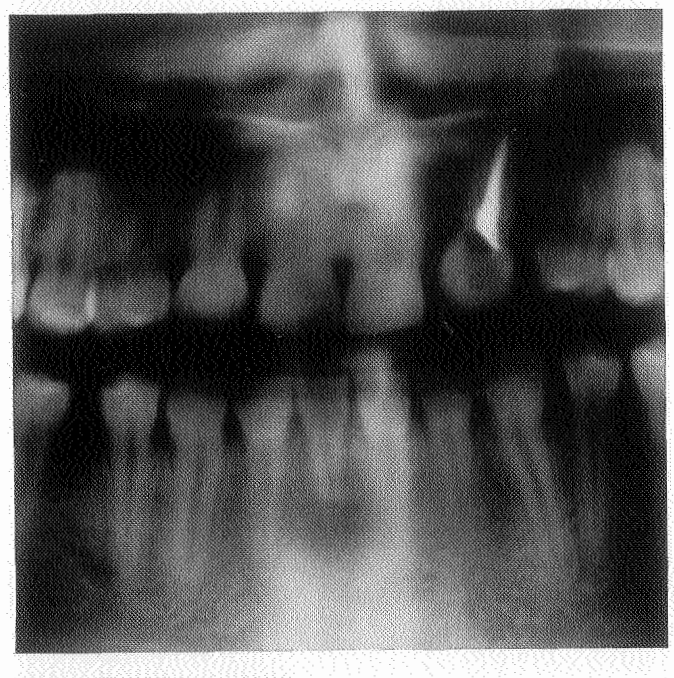

Figure 6(b). OPG of 17/7/87

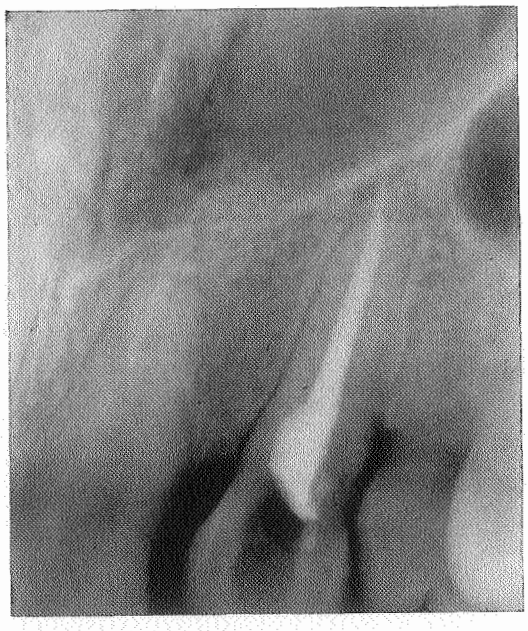

Figure 6(c). Periapical of 17/7/87

apparent within six months, the procedure should be repeated. If the luxation technique is unsuccessful a second time the tooth should be extracted. He declared that J.D. Peak, Austin, Texas, follows luxation with gentle orthodontic movement by means of springs. Elastics may also be used. (No mention was made of a recommended time interval between luxation and the application of orthodontic traction). The springs or elastics cause the tooth to be mobilised promoting the formation of fibrous tissue and preventing re-ossification. Biederman illustrated two cases of ankylosed permanent molar teeth successfully freed with the luxation method but no cases treated with luxation followed by orthodontic traction were described.
4. In some circumstances an ankylosed tooth should be left undisturbed.

Helmore and Norton (1953) each authored one part of a two-part article about the unerupted canine. Helmore said that three surgical methods exist to uncover the canine.
(a) Simple excision of overlying tissue
(b) Raising a muco-periosteal flap, removal of bone, stimulation of the tooth by slight instrumentation and replacement of the flap. This is referred to as the 'Stimulation technique'.
(c) Raising a flap, removal of the coronal sac, channeling of the bone, stimulating eruption by gently moving the tooth in all directions with a suitable elevator (he described this as 'wiggling' of the tooth), cutting a window in the flap and, after resuturing, packing to prevent healing over of the soft tissues.

Helmore stated that this last technique is the method of choice.

Kaban et al. (1976) illustrated 5 cases of permanent molars failing to erupt, without any known cause. In 4 cases the teeth were uncovered and gently luxated to an upright position at the crest of the alveolar ridge. All the teeth actively erupted into occlusion and root development continued. They stated that these 5 patients raise questions about the physiology of tooth eruption.

Epker and Paulus (1978) published an article describing six variations of single-tooth dento-osseous osteotomies in which teeth were repositioned manually and/or orthodontically. Some of the cases were of successfully treated ankylosed central incisors. An important aspect for one-stage dento-osseous osteotomies with immediate orthodontic movement on the teeth-bone segment is that immediately after surgery (the same day the operation is performed) the actual orthodontic movement is begun with an attempt being made to complete it in 2 to 4 weeks.

Azaz et al. (1980) surgically exposed 121 unerupted teeth. Surgery comprised:
(a) exposure
(b) exposure and traction (mainly by means of a stainless steel ligature applied to the neck of the unerupted tooth) or
(c) exposure and repositioning.

Approximately half the number of teeth were treated by exposure alone, one quarter with exposure and traction and the remaining quarter with exposure and repositioning.

Of the 121 operated teeth 10 were considered to be failures, i.e. they did not assume their functional position in the arch and were not asymptomatic. Six of the 10 failed cases had evidence of replacement resorption (ankylosis). At least 3 of the 6 had been repositioned and 1

lassooed. Twenty-six of the successfully treated teeth had biologic aberrations such as:
(a) reparative dentine formation with pulpal obliteration
(b) formation of dwarfed roots
(c) non-response to vitality tests.

They showed that *a direct relationship exists between the extent of development of pathophysiologic aberrations and the intensity of the manipulative injury.*

Shaw et al. (1981) reported on a sixteen year old patient who had ankylosed (and impacted) maxillary canines. Orthodontic treatment had failed to move the canines and therefore they were transplanted. The transplants were still satisfactory 30 months later.

Skolnick (1980) discussed a case of a patient with an ankylosed permanent maxillary right first molar which was unerupted at ten years of age. He stated that the tooth was loosened in a manner similar to Hemley's suggestion (1971) which was to rock the tooth bucco-lingually with extraction forceps and antero-posteriorly with a spear-pointed elevator. Skolnick reported that the first molar had erupted completely twenty one months after rocking and responded positively to vitality tests.

Andreasen (1981) said a late complication following luxation injuries is root resorption and that external root resorption occurs much more commonly than internal root resorption. The aetiology and pathogenesis of the external root resorption seem to be identical to root resorption following replantation of exarticulated teeth.
Three types of **external root resorption** can be recognised:
1. Surface resorption
2. Inflammatory resorption
3. Replacement resorption where histologically a direct union between bone and root substance is seen, the tooth substance being gradually replaced by bone. Radiographically, disappearance of the periodontal space and progressive root resorption are typical findings.

Andreasen uses the term replacement resorption as a synonym for ankylosis and says that teeth with replacement resorption do not respond to orthodontic treatment and consequently orthodontic treatment is not indicated.

Proffit and Vig (1981) wrote that there are two possible causes **why posterior teeth fail to erupt** partially or completely:
1. Mechanical interference with eruption either before or after the tooth emerges from the alveolar bone
2. Failure of the eruptive mechanism of the tooth to produce the necessary amount of eruption
1. Mechanical interference with eruption may be caused by ankylosis of the tooth to the alveolar bone or by obstacles in the path of the erupting tooth. Examples of obstructions prior to emergence are supernumerary teeth and non-resorbing deciduous tooth roots or alveolar bone. After the tooth emerges from the bone, pressures from soft tissues interposed between the teeth (cheek, tongue, finger) can obstruct eruption. When a tooth erupts into the oral cavity and then ceases eruption before growth is completed, it appears to submerge. This submergence usually denotes ankylosis.
2. Failure of the eruptive mechanism
Proffitt and Vig termed this 'primary failure of eruption' and described some of its characteristics such as:
(a) involved teeth may erupt all the way into occlusion and then cease to erupt even though they are not ankylosed or they may fail to erupt even though the overlying bone has been removed by apparently normal resorption to provide an eruption path
(b) involved permanent teeth do tend to become ankylosed but failure of eruption is apparent before definite ankylosis occurs. When an unerupted molar is surgically exposed in a patient with this condition the surgeon usually observes that the tooth is not ankylosed and can be moved within the crypt.
(c) application of orthodontic force in an attempt to bring involved teeth into the arch leads to ankylosis.

Bower and Reinhardt (1982) described a case of a 55 year old man who possessed two ankylosed and partially erupted maxillary canines. Conventional fixed orthodontic therapy had failed, and so that patient was provided with porcelain fused to metal crowns to give the canines adequate aesthetics and function. Two and a half years after treatment the result was stable and aesthetic.

Andersson et al. (1984) discussed the assessment of tooth ankylosis by clinical, radiological and histological means. They stated that a correct diagnosis of ankylosis (based upon experiments on replanted incisor teeth in monkeys) was possible by means of mobility and percussion tests, when 20% or more of the surface was involved. The percussion and mobility tests were more sensitive and accurate than the radiographically observable changes of the width of the periodontal membrane.

Israel (1984) presented a case report of a patient with arrested permanent posterior teeth eruption, the only posterior occlusal contact being on the second molars. There was hypercementosis present, a reduction in the periodontal ligament space and ankylosis. A similar occlusion occurred in four members of the same family and it appeared to have an autosomal dominant mode of inheritance.

Oliver et al. (1986) presented 4 case reports of permanent molars which were not at the level of the occlusal plane. They commented on and amplified some of the work of Proffit and Vig (1981) who had introduced the term primary failure of eruption (see above). Oliver et al. (1986) categorised their cases as either 'primary arrest of eruption' if the molars had failed to maintain occlusal height following eruption (two cases) or 'primary failure of eruption' if the teeth failed to emerge from their crypts within the alveolus (two cases). They uncovered one tooth in this latter category but since it failed to erupt, it was later extracted. In the other case the molar was extracted without a prior attempt at uncovering. Only one of the two extracted teeth was available for histological inspection. It had a normal root surface with no sign of ankylosis. Oliver et al. (1986) stated that the work of Cahill and Marks (1980) suggested that their cases of primary failure of eruption were due to a fault of the dental follicle which failed to initiate the metabolic events responsible for tooth eruption. They said that their cases of primary arrest of eruption had a different aetiology from the primary failure of eruption cases. The choice of title for their article 'Submerged permanent molars - four case reports' is unfortunate because the word 'submerged' is usually used in the context of erupted teeth that appear to become depressed compared with their neighbours which continue to erupt. Yet two of their cases were of teeth which had never erupted.

Proffit et al. (1986) wrote 'Ankylosis of an unerupted tooth is always a potential problem. If an area of fusion to the adjacent bone develops, orthodontic movement of the unerupted tooth becomes impossible, and displacement of the anchor teeth will occur. Occasionally, an unerupted tooth will start to move and then become ankylosed apparently held by only a small area of fusion. It can sometimes be freed to continue movement by being anaesthetised and lightly luxated, breaking the area of ankylosis. If this procedure is done, it is critically important to apply orthodontic force immediately after the luxation, since it is only a matter of time until the tooth reankyloses. Nevertheless, this approach can sometimes allow a tooth to be brought into the arch, which otherwise would be impossible to move.' Proffit did not present any cases.

Jacobs (1987) discussed the surgical exposure of teeth and illustrated some cases of patients with unerupted permanent lower molars (and premolars) which, after uncovering, subsequently reached the occlusal plane without further assistance.

Vanarsdall (1981, 1985) published articles on aspects of the relationship between orthodontics and periodontics. In May 1988 Vanarsdall lectured exhaustively on this topic[#] and discussed ankylosis as part of his presentation.

Types
Vanarsdall differentiated at least four types. Ankylosis in:
(a) the young patient
(b) the older patient
(c) the traumatised tooth
(d) the reimplanted tooth

Histological cause
At the histological level ankylosis arises because of damage to the cells on the root side of the periodontal ligament (PDL). Other cells from the bone side of the PDL can migrate and resorb tooth substance.

Aetiology
Damage to the root surface cells and subsequent ankylosis can arise in a number of ways.
(a) If an attachment is placed that impinges on the root this can kill cells
(i) Dead soft stainless-steel wire loops were implicated in a large number of the 40 patients with 55 ankylosed teeth that Vanarsdall reported about to an American Association of Orthodontists Annual Session in the late 1970s.

Radiographs frequently showed resorption occurring within 1-2 weeks of placing the loop. The wire impinges on the root because it cannot conform to the cemento-enamel junction.
(ii) An over-extended crown form can also damage the root cells
(b) If a tooth is etched in preparation for a bonded attachment at the time of uncovering the etch can flow onto the root surface at the cemento-enamel junction and cause damage.
(c) If a tooth is luxated at the time of uncovering this can cause damage to the PDL.
(d) Trauma and
(e) Reimplantation can cause damage also.

Treatment
(a) *Flap formation*
If the tooth is unerupted Vanarsdall recommends incisions for apically repositioned flaps, both facially and lingually if this is practicable.

(b) *Luxation*
Essentially the tooth is almost extracted from its socket. The tooth should be twisted free and pumped up and down vertically 2-3 mm. The ankylosed spot often will not break until the tooth is moved vertically, especially if the tooth is multi-rooted. This rarely devitalises the tooth.

(c) *Bone removal*
If there is resorption in the region of the crestal bone then the bone which is resorbing the tooth is removed. Fortunately many ankylosed teeth do not have crestal external root resorption.

(d) *Attachment and traction*
An attachment should be bonded immediately and traction applied to the ankylosed tooth. (Vanarsdall feels virtually all unerupted teeth in any position can be bonded and that there is never any justification for the use of stainless steel loops. However, as indicated earlier, if an unerupted tooth is *not* ankylosed, an attachment should not be bonded at the time of uncovering. This is because it is desirable for follicular tissue to cover the cemento-enamel junction so that rinsed etch will not run towards the apex and damage the root. Vanarsdall bonds seven days after uncovering labial teeth and ten days after uncovering palatal teeth.) Freed teeth should be reactivated every seven days, i.e. they should not be given the opportunity to re-ankylose. The operator should take a radiograph the day the tooth is luxated and then at two-weekly intervals to ensure that resorption is not occurring.

A useful clinical guide to determine the efficacy of luxation and traction is, after a few days to ask the patient which teeth are sore. If other teeth are sore then the wrong teeth are moving!

(e) *Amount of movement*
If there is resorption then the tooth should be erupted 3-4 mm beyond the defect so that the dentist can place the margin of the restoration in sound tooth structure. If the tooth is elongated sufficiently so that there is a normal PDL it will not re-ankylose. Some teeth need to be endodontically treated because so much of the tooth crown has to be removed during extrusion.

A maxillary canine can be extruded 6-7 mm and still have adequate root length for placement of a restoration.

(f) *Retention*
Forcibly erupted teeth have a tendency to re-intrude. If the clinician is concerned that the tooth will have a tendency to re-intrude whilst the appliances are still in place he may reflect facial and lingual flaps and re-attach them to the tooth. This procedure will stabilise the tooth.

(g) *$Ca(OH)_2$*
Vanarsdall stated that the suggestion to use $Ca(OH)_2$ to arrest replacement resorption was not a successful treatment procedure.

Prognosis
(a) The success rate is excellent with adults who have single-rooted teeth with spot ankylosis
(b) Molars are often ankylosed in the furcation area and there may be through and through furcation involvement when movement is finished
(c) The healing potential of young patients (8-9 years old) is so much greater than for adults that resorption will often destroy much of the tooth. Some molars of children re-ankylose after treatment.
(d) Sometimes if the tooth is moved rapidly the bone remains osteoid. Only when the tooth is brought into the arch and movement ceases does the bone calcify and resorb the tooth. There are different rates of resorption for different patients.
(e) Traumatised teeth with resorption below the alveolar crest have a hopeless prognosis.

Precaution
If extractions are necessary and the operator wishes to bring an unerupted and/or ankylosed tooth into the arch then one must ensure that the doubtful tooth is moving before a sound tooth is removed.

Cases
At the Sydney meeting, Vanarsdall showed a variety of cases of successfully treated ankylosed teeth. One case, an ankylosed premolar in a 37 year old is illustrated in his 1985 article (Vanarsdall 1985). For a second patient he salvaged an ectopic (unerupted) and ankylosed lower third molar, in a 58 year old, for use as a bridge abutment. For a third patient (who was 52 years old) he distalised the

maxillary arch in a Class II malocclusion using the ankylosed maxillary central incisor for anchorage. Then the incisor was luxated and a constant force used to retract it. In a fourth case he showed how to remedy an open bite which occurred during orthodontic treatment because a permanent first molar was ankylosed. He used the ankylosed tooth as anchorage to re-extrude the affected teeth, i.e. he reversed the mechanics. The reaction to attempting to intrude the first molar was to extrude the moved teeth.

COMMENTS

Originally it was considered that a suitable title for this case report could be 'An ankylosed maxillary canine - report of a successfully treated case' - for the ankylosed tooth was brought into a satisfactory position and has continued to remain so three years four months after debanding, i.e. it has not reankylosed, nor are there any radiographic signs of further resorption.

However, the situation where:

(a) a tooth may have become ankylosed as a result of surgical manipulation (injury no.1)

(b) a tooth has been devitalised as a result of dental procedures (injury no.2)

(c) a tooth probably has had its crown damaged during surgery (injury no.3) and

(d) the orthodontist was not suspicious from commencement of treatment that 23 was ankylosed (since a previous history existed of uncovering, possible stimulation and non-eruption) cannot be endorsed with the claim of being successfully treated.

Injury no 1

The part of the uncovering method described by Helmore (1953) that may give rise to concern is the 'Stimulation technique'. If done over-zealously it could result in a situation analogous to a subluxation with subsequent ankylosis. The tooth in this case report may have been 'stimulated' on two occasions.

Injury no 2

The 23 was surgically rotated 45 degrees rather than being rocked bucco-lingually and antero-posteriorly as in the technique recommended by Hemley (1971). This rotation may well have damaged the apical vessels resulting in devitalisation of the tooth.

Injury no 3

The enamel appears intact in *Figure 1* of 17/2/82. A defect in the enamel was noted at the time of surgery in February 1983 and can be seen in *Figure 2* of 8/6/83. The enamel may have been damaged during the uncovering procedure of 26/8/82.

Because of the concern about ankylosis and the difficulties associated with treating it, some orthodontists recommend that whenever a case with impacted maxillary canines requires extractions, the extractions are postponed (if possible) until the canines have been uncovered and are seen to be moving. However, as Proffit (1986) pointed out, sometimes an unerupted tooth will commence to move and then will become ankylosed.

CONCLUSIONS

The non-obstructed permanent teeth most commonly unerupted (partially or completely) are the molars. Teeth that have been traumatised (particularly if they have been avulsed or luxated) have a high incidence of ankylosis. Sometimes impacted canines are ankylosed. Cases have been reported of patients who have multiple ankylosed teeth; occasionally a family history has been identified.

The scope of treatment available ranges from non-interference up to extracting the tooth. In between these two extremes various treatment methods have been recommended. Sometimes unerupted molars, if uncovered, do reach the occlusal plane without further assistance, therefore, these molars are not ankylosed. Some unerupted molars do not erupt when uncovered and yet many of these molars do not exhibit any evidence of ankylosis. Luxation followed immediately by orthodontic traction is a recommended treatment for ankylosed teeth and was the technique used for the ankylosed maxillary canine of this case report.

Other forms of treatment, which may be appropriate when suitable indications exist are:

(a) uncovering molar teeth and luxating them to the crest of the alveolar ridge

(b) single tooth dento-osseous osteotomies followed immediately by repositioning manually and/or orthodontically

(c) transplantation

(d) building up the tooth to restore occlusal and proximal contacts and to improve aesthetics.

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