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CLINICAL SECTION

Dental trauma: part 2. Managing poor prognosis anterior teeth – treatment options for the subsequent space in a growing patient

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Part 1 concentrated on implications of dental trauma especially prior to and during orthodontic treatment. This paper examines the literature supporting various treatment options for poor prognosis anterior teeth and subsequent space generated when these teeth are lost. The role of an interdisciplinary team in managing this clinical situation is essential to obtain optimal results and an orthodontist is an essential member. Although some treatment options are not provided by orthodontists it is important that they have some knowledge of these and the latest research that support their use. Other techniques lie very much within the orthodontic remit.

Treatment options can be split into maintaining the failing tooth or extraction and restoration of the edentulous gap. This paper reviews various treatment options including periodontal regeneration, surgical repositioning and distraction osteogenesis, composite build up to incisal levels and decoronation when maintaining a failing tooth. When extraction and restoration of edentulous gap is required the following treatment modalities are discussed: extraction technique to retain bone quantity, orthodontic space closure and opening (site development), autotransplantation, partial denture, resin bonded bridge and implants. All these options should be considered and available to an interdisciplinary team to ensure optimal care of children with anterior teeth of poor prognosis.

Key words: Dental trauma, avulsion injuries, ankylosed teeth, autotransplantation, replacing missing anterior teeth

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Introduction

The prevalence of missing anterior teeth as a result of dental trauma is reported as 12 per 1000 children in one cross-sectional epidemiological study.[1] Consequently, although rare in a growing child, failing or missing anterior teeth as a result of dental trauma is a complex area requiring specialist interdisciplinary planning and treatment. The team should have core members comprising a paediatric dentist and an orthodontist but should also on occasions be able to call on the expertise of a restorative dentist and oral and maxillofacial surgeon. The general dental practitioner (GDP) should be kept informed of all decisions, outline treatment plans and progress. In some situations, the GDP can provide some of the restorative options discussed later, especially if this reduces time taken off from school and work. Finally, it is essential that children and parents attend for regular check ups with their GDP to ensure the rest of their dental health is looked after.

Failing anterior teeth need to be identified as early as possible so that the child and parent are fully informed of the prognosis. All treatment options can then be considered and planning can start for the short, medium and long term. In additional treatments of little benefit, unless requested by the child, can be avoided to prevent unnecessary addition visits or expectations. Nyugen[2] has reported the considerable burden of care these children

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require, resulting in significant direct and indirect costs to the family.

The choices of treatment for failing anterior teeth are dependent on the characteristics of each specific situation. The team must take into account the age of the patient, growth potential, occlusion, oral hygiene, caries status and motivation towards dental health in addition to patient compliance. The ideal outcome in the young patient with poor prognosis anterior teeth is to preserve bone and soft tissues as long as possible to improve the restorative options that can be offered in early adulthood after growth has ceased. Treatment options fall into two broad categories; retention of the maxillary incisor as long as possible or removal of the failing tooth at the most appropriate time. This article will split failing anterior teeth into three categories as not all treatment options are available or appropriate for each group. It is vital that orthodontists are aware of the possible management options for these patients since each will impact upon the orthodontics, and the orthodontic possibilities will impact on the treatment options.

Group 1 – crown/root fracture following previous apexification (Figure 1)

The first group comprises those teeth which have suffered pulp necrosis at an early stage of development leaving the tooth with immature root formation. Such teeth require apexification (generation of a hard tissue barrier against which a root filling material can be packed). Materials and techniques used for apexification are beyond this article but are well-discussed in literature.[3,4]

Currently no apexification technique has a proven track record of reinforcing the weakened root form of an immature non-vital tooth and there are worries from laboratory studies that long-term use of non-setting calcium hydroxide may in fact make the dentine more brittle.[5,6] A clinical follow-up study has reported that for these weak, immature teeth there was between a 25–75% chance of subsequent crown/root fracture in later years.[7] When this occurs a non-vital root is left with a healthy periodontal ligament. These roots can frequently be left *in situ*,[8] unless a better treatment option is available, to maintain the associated bone and gingival contour. Frequently the gingival tissue will heal over the root face. In an audit of 49 cases of intentionally retained permanent incisor roots with a normal periodontal ligament, following crown root fracture only five roots had to be extracted. These were due to persistent infection during a follow-up period of 0.6–6.8 years.[8] This emphasizes the importance (discussed later in Decoronation) of ensuring that any root left *in situ* must be infection-free with appropriate endodontic therapy undertaken. It is essential therefore that these roots are then monitored clinically and radiographically over the short to medium term. The retained root will maintain its vertical position within the alveolus, preserving both buccopalatal and vertical bone for future restorative options.

Figure 1 Crown/root fracture of immature UL1 with poorly obturated non setting calcrum hydroxide in situ

Various restorative options are available to replace the missing crown and are discussed later. The same situation arises with coronal root fractures when the very mobile coronal crown portion is extracted and the apical root fragment is left *in situ* without complications.[9]

Group 2 – recurrent infection

The second group are those where the pulp canal space, despite best endodontic efforts, cannot be rendered infection-free. Examples of this are a small number of open apex cases or where the crown/root fracture either extends subalveolarly, or, on occasion, where multiple fractures may occur within the tooth, or both, rendering adequate endodontic intervention impossible. Another

example is extensive inflammatory resorption which is identified late and the clinician is unable to disinfect the root canal sufficiently to prevent further progressive resorption. In these situations, the entire tooth must to be removed to alleviate symptoms and prevent further loss of bone either apically, laterally or both. Consequently at relatively short notice (over a matter of weeks to months) a treatment plan needs to be devised to restore the subsequent space and where possible prevent the associated bone loss related to the extraction of the tooth.

Group 3 – Ankylosis and replacement resorption

This scenario results from severe periodontal injuries, mainly as a result of an intrusion or avulsion. Ankylosis can also develop following inflammatory resorption were the damage to the cementum has resulted in a defect beyond the critical size for healing by favourable (cemental) healing.[10] In these situations the root will slowly be replaced by bone (governed by the age of the patient and speed of bone turnover)[11,12] and eventually lost. There is, therefore, often a significant length of time for the team to weigh up the different treatment options available.

Avulsion injuries

Although damage to the cementum during an avulsion is considerably less than an intrusion injury, it is the consequent drying and storage prior to replantation that has a severe effect on how the protective layer of the tooth root will heal. Every effort should be made to replant the tooth as soon as possible[13–16] with parents or bystanders encouraged to replant at the site of the accident. It has been shown that after 60 minutes extraoral time,[13–16] even when stored in milk, or 30 minutes dry time[11] replacement resorption is almost always guaranteed. Replanting a tooth outside these maximum time periods has two consequences. First, the avulsion injury is no longer an emergency as the prognosis is not time dependent and second a more complex decision is required to determine what benefits replanting the tooth will be in the future management of the patient's dentition. In these situations, good interdisciplinary team planning is critical. Advice to emergency care providers is still to replant and splint the tooth but to refer to a specialist team as soon as possible with the explanation that the tooth may be extracted in the short, medium or long term. This ensures that all possible options are available for the team to work with.

Figure 2 Severe infra-occlusion in a 12-year-old as a result of ankylosis of UL1 following avulsion and replantation 5 years earlier

Diagnosis of ankylosis

An ankylosed tooth is classically detected by a high resonant tone heard on percussion testing. This pathognomic sign is present only after approximately 20% of the root surface area is affected by replacement resorption.[11] Ankylosis is almost always detected 2–12 months after the injury.[14,17] Early radiographic diagnosis is often difficult as the site of initial replacement resorption is usually on the buccal or palatal root surface which is difficult to image with current two-dimensional standard radiographic techniques.[11,18] A temporary ankylosis phenomenon has also been described with reduced mobility readings initially which then recover by 8 weeks, as normal cemental healing occurred.[11,19] By 12 months the chance of ankylosis subsequently developing is remote.[14,17] This explains the recommended observation period of 12 months prior to orthodontic movement of severely traumatized teeth discussed in Part 1.[20] The only true way of detecting ankylosis is if the tooth will move under orthodontic forces or with physiological growth. Following significant dental trauma orthodontists should have a lower threshold in suspecting ankylosis where the tooth fails to respond to orthodontic forces.

Speed and effect of infraocclusion for ankylosed (group 3) teeth

When ankylosis tooth is detected, the subsequent vertical growth of the adjacent alveolar process, tooth and soft tissues (gingival margin) will cease resulting in localized infra-occlusion of the dentoalveolar complex. In a growing child if allowed to progress for too long a severe effect on aesthetics and treatment options is encountered (Figure 2). The difficulty is deciding when the benefits of maintaining buccal/lingual bone are

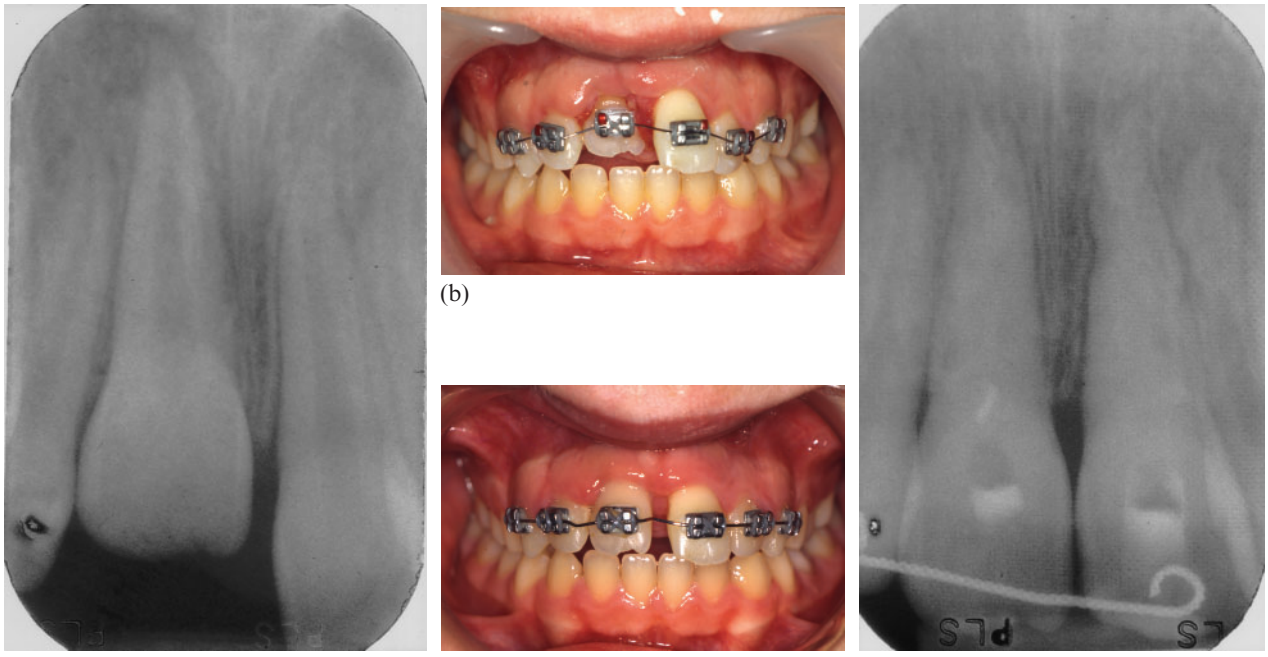

Figure 3 (a) Periapical radiograph of ankylosed UR1 in a 16-year-old patient. (b) Extrusion of UR1 following forced luxation, using 0.012-inch nickel titanium. (c) Continued extrusion of UR1. (d) Periapical radiographs showing calcium hydroxide dressings in non-vital UR1 and UL1. Surface resorption is seen affecting UL1

outweighed by the cosmetic defect and disruption to the arch form. Malmgren and Malmgren[21] analysed the rate of infraposition of ankylosed incisors in 30 growing subjects over a period of 1–10 years. They concluded that diagnosis of ankylosis before the age of 10 years, or before the growth spurt, was associated with severe infraposition. In these cases, they recommended the tooth is extracted, decoronated or replaced by a transplant within 2–3 years. If the injury and subsequent ankylosis develops at a later stage, e.g. during the pubertal growth spurt, they recommended regular monitoring, without intervention, provided adjacent teeth do not tilt towards the infrapositioned tooth.

Retention of ankylosed central incisor (group 3) – treatment options

Where the team have elected to retain the ankylosed anterior tooth to maintain bone and soft tissue in the area what treatment options are available?

Periodontal regeneration

At the present time, there appears to be no treatment modality available that is able to reverse replacement resorption once it has started. Currently prevention of replacement resorption in the first place would appear to be a more realistic goal with replantation as soon as possible and appropriate follow-up care for these severe injuries.

Surgical repositioning and distraction osteogenesis

A few case reports describe forced luxation and orthodontic tooth movement to reposition ankylosed teeth (Figure 3a–d). This technique assumes that the forced surgical luxation disrupts the area of ankylosis, the consequent inflammatory reaction resulting in formation of a connective tissue attachment, allowing orthodontic tooth movement.[22,23] Unfortunately, in many cases, the repair process usually results in a recurrence of the ankylosis, even following orthodontic traction.[24] More recently the technique of single tooth osteotomy and distraction osteogenesis has been shown good results in case reports,[25,26] with the ankylosed tooth serving as anchorage for orthodontic correction of the malocclusion and as the point of force application for a dentoalveolar segment during alveolar distraction osteogenesis. In this technique the tooth will continue to undergo replacement resorption and will be eventually lost.

The team should recognize that it is not possible to move teeth orthodontically once ankylosis has developed. Indeed the application of orthodontic forces to

Figure 4 Composite build-up of ankylosed UL1 showing disparity of gingival margin between UR1 and UL1 in a young growing child

ankylosed teeth can cause undesirable intrusive movement of anchorage teeth. Whilst the techniques of forced luxation and single tooth osteotomy with distraction osteogenesis have been described, re-establishment of the ankylosis with continued infra-occlusion (in the growing patient) should be anticipated. These techniques will, however, help to maintain bone and soft tissue, allowing a more comprehensive array of restorative solutions, with optimum aesthetics, to be offered in adulthood.

Composite build-up to incisal level

Restoration of the infra-occluded tooth by composite build-up techniques to improve aesthetics may be a desirable short term measure and is particularly suited to an older patient in the post-pubertal growth spurt phase. In a growing patient with a high smile line the disharmony in the gingival contour between the infra-occluded and uninjured tooth, and the long appearance of the restored infra-occluded tooth may be unsightly (Figure 4). Although this technique is best regarded as a temporary solution, and both patients and parents should be advised accordingly, the maintenance of an ankylosed tooth is of value in maintaining bone volume for later restorative care. Composite build-up of the incisal tip of a tooth is a simple, non-invasive and effective solution, provided very little further infraposition is expected.

Extraction and alveolar resorption following tooth loss

Extraction of a failing anterior tooth is frequently a treatment option of choice for teeth with recurrent infection and ankylosed teeth (groups 2 and 3). In the former situation (group 2) persistent infection despite endodontic treatment will necessitate the tooth's prompt removal. In the latter group of patients (group 3), extraction of a central incisor of poor prognosis may be warranted if the tooth is ankylosed and the patient is pre-pubertal. Severe infra-occlusion in the growing phase can be anticipated, with a concordant severe vertical bony deficiency which would require later surgical augmentation of bone and soft tissue to improve aesthetics.

The extraction of the failing tooth must be weighed up against the effect on the alveolar complex. Rodd *et al.*[27] reported that alveolar ridge thickness depreciated by 20–30% in the bucco-lingual direction on extraction of a maxillary central incisor in comparison to the control, the unextracted adjacent incisor. This makes future implant placement in this region difficult, with bony augmentation necessary to facilitate correct placement and aesthetics of the prosthetic crown. The use of coral granules post-extraction with the aim of preventing such a reduction in bone width has been investigated.[28] Unfortunately, in the anterior maxilla they were unable to prevent the necessity of surgical ridge augmentation prior to placement of implants 3–8 years later, in 14 out of 17 cases described. Other authors[29] have reported on several possible surgical treatment modalities which may be useful in the reconstruction of narrow anterior alveolar ridges prior to implant placement. These include bone grafting, bone substitutes to guide bone regeneration, osteocompression, distraction osteogenesis and crestal split osteotomies. All are invasive surgical techniques requiring considerable surgical expertise, expense and good patient compliance. To minimize the need for later bony and soft tissue augmentation to facilitate osseointegrated implant placement, atraumatic techniques of tooth removal should be employed.

Decoronation

Decoronation of a tooth undergoing replacement resorption helps to maintain bone width (buccopalatally), and in some cases is reported to promote the vertical bone growth over the root surface.[30,31] An atraumatic technique for the surgical removal of the crown undergoing replacement resorption has been described.[32] The crown and root filling are removed leaving the root *in situ* to be resorbed by the process of replacement resorption. The retained root is then covered with a mucoperiosteal flap. The importance of ensuring that any root or tooth left *in situ* to maintain bone must be infection free has been shown in an audit of the success rates and complications occurring for implants placed to rehabilitate the anterior maxilla.[33] Any roots intentionally retained must therefore be monitored clinically and radiographically and endodontically treated or removed if infection arises. The missing crown can be restored with either a partial denture or

Figure 5 (a) Loss of UR1 with bodily drifting of UR2 into the space. (b) Composite build-up of UR2 to give the orthodontist an indication of the final tooth size prior to space closure. (c) Orthodontic levelling prior to space closure. (d) Definitive restoration of UR2 to mimic UR1 and UR3 to mimic UR2

resin bonded bridge (RBB); the latter may even utilize the failed crown portion as the pontic.

Treatment options available for the restoration of the edentulous space

These treatment options discussed below are available to all groups but may require some treatment prior to starting e.g. carefully extracting the remaining root for group 1 patients prior to transplantation or orthodontic space closure.

Orthodontic space closure

Kokich and Grabill[34] suggest leaving nothing in the edentulous space, allowing adjacent teeth to move together and thereby closing the space. The authors state that erupting teeth drift bodily together in a growing child bringing alveolar bone with them. They recommend either orthodontically re-opening the central incisor space once other permanent teeth have erupted or restoratively modifying the maxillary lateral incisor and canine to mimic the contralateral central and lateral incisors. In this technique space re-opening is referred to as 'orthodontic site development'.[34] As the maxillary lateral incisor and contralateral central incisor are pushed apart, bone is created in the developing edentulous space. From results of previous research they claim the bone produced during 'orthodontic site development' does not resorb or become narrower over time[34,35] and thus an improved site is available for pontic or implant placement. The main disadvantage of this approach is acceptance of temporary poor aesthetics as the lateral incisor is allowed to drift into the central incisor space. Therefore, it may be a treatment option many teenagers and parents would reject.

If space closure occurs and a decision is made to modify the lateral incisor (Figure 5a–d) it is important that both the lateral incisor and canine are amenable to modification to allow an aesthetically pleasing result. Intrusion of the lateral incisor and extrusion of the canine will be required in an attempt to reflect the gingival contour of the central and lateral incisors. Czochrowska *et al.*[36] examined a sample of 20 consecutive patients treated by orthodontic space closure and composite modification of the lateral incisor, comparing the clinical appearance with the contralateral incisor and asking for the patient's opinion of the end

result. The authors noted 25% of the restored teeth had a slight aesthetic mismatch to the adjacent central incisor, with some having an increased pocket depth on the mesial aspect. Most patients, however, were satisfied with the end result. The authors comment that although the colour and morphology of the recontoured tooth frequently did not completely match those of the contralateral incisors, mesialization of the lateral incisor maintains the appearance of the gingival soft tissue around the tooth, which can be difficult to obtain with a partial denture, resin-bonded bridge (RBB) or implant. Relative contra-indications to the movement of the lateral incisor to the central incisor space include Class III cases, spaced maxillary incisors and lateral incisors with a small crown shape.

Autotransplantation

Tooth autotransplantation has been shown to be a highly successful technique. It is frequently the treatment of choice in a motivated and compliant paediatric dental patient with traumatized incisors of poor prognosis in whom orthodontic extractions are indicated (Figure 6a–i).

Autotransplantation is a unique treatment option for the growing patient because it provides a natural tooth replacement.

Advantages:

- Bone generation: autotransplanted teeth retain the potential to induce alveolar bone growth during the eruption process and to aid bony infill at sites of deficiency.[37] Bone inductive properties are particularly useful when there has been traumatic loss of anterior teeth which has also involved the loss of supporting bone.
- Ability to orthodontically move the transplanted tooth: a successfully transplanted tooth has a normal marginal gingival contour and the restoration of a functional periodontal ligament following healing allows the graft tooth to be moved orthodontically. This allows the surgeon to place the tooth in the optimal position for periodontal ligament survival — and hence long term tooth survival — safe in the knowledge that when successful, the tooth can be moved orthodontically into the optimal position prior to definitive composite modification.
- Success and survival: care has to be taken when reviewing the literature to ascertain if the authors are reporting survival (tooth present but may or may not be undergoing replacement resorption) or success rates (tooth present and periodontal ligament healing has taken place). Where successful healing occurs the tooth will last as long any other uninjured tooth. At ten years, success and survival rates are very good with success rates reported of between 87 and 93% and tooth survival between 90 and 98%.[38] An even longer retrospective study of 30 autotransplants in 25 young patients (mean age 11.5 years) with follow-up times of 17–41 years (mean 26.4 years) found a success rate of 79% and has provided further evidence of the value of the technique of tooth autotransplantation in a paediatric dental population.[39] Even in the few cases where ankylosis occurs, the transplant will slowly resorb, depending on alveolar bone turnover rate and thereby maintain bone in the area for future treatment options.

Disadvantages:

- Autotransplantion for a failing anterior tooth is only an option for children in whom orthodontic extractions are indicated.
- Treatment burden: from the initial discussions with the children and parents, both need to be fully aware of the time and number of visits required.
- For the majority of children, autotransplantation is undertaken under general anaesthesia or sedation.
- Aesthetics: the aesthetics of 22 autotransplanted and restored premolars were compared to their natural contralateral maxillary incisors, assessing colour, soft tissue appearance, tooth morphology and position. Clinically, 14% of the sample was characterized as a mismatch when compared to the contralateral tooth and 18% of the patients expressed dissatisfaction.[40] Therefore even in the anterior maxilla the vast majority of patients are satisfied with the appearance of the transplanted tooth. Parents and children do need to be warned however, that there will be a short period prior to crown build up and orthodontics when aesthetics will be poor.

Careful interdisciplinary management is essential and the team should see the child as soon as the failing anterior tooth is identified. The sequence of treatment frequently progresses along the following pathway:

- Treatment planning: extraction patterns for correction of malocclusion is outside the scope of the article, but at this initial meeting with the team the first decision to make is whether the teeth or tooth are available for transplantation (e.g. orthodontically indicated for correction of the child malocclusion). The second decision is to decide which teeth are most advantageous for the surgical transplantation but also to achieve good orthodontic correction. The mandibular first and second premolars are particularly suitable for transplantation to the incisor region of

Figure 6 (a) Orthopantomograph showing loss of UR1 and UR2 but adequate bone available for a premolar transplant. The donor (UL4) is single rooted and has 3/4 root length. (b) Anterior view with missing UR1 and UR2. (c) Palatal view shows anterior crowding. Sufficient bone available in a buccopalatal direction for a premolar transplant. (d) UL4 in position of UL1. (e) Slight extrusion of UR1 commenced after 6 weeks. (f) Temporary composite build-up of premolar transplant giving final mesiodistal width of UR1. (g) Premolar transplant shows continued root development and pulp canal obliteration. UL1 shows apical root resorption following orthodontic tooth movement. (h) Final occlusion showing composite build-up of premolar transplant, modification of shape of UR3 to mimic UR2 and good buccal interdigitation. (i) Good left buccal interdigitation

the maxilla as a result of their root anatomy.[38] If they are not available the maxillary second premolar can be used. Donor teeth ideally need to be easily extracted, as indicated in a retrospective audit carried out in a paediatric dental population. While good success rates were reported for donor teeth that were

easily extracted, success rates for teeth requiring surgical extractions or surgical preparation of the recipient site were reduced.[41]

- Pre-surgical orthodontics to improve the recipient site is sometimes necessary. This is usually due to an undesirable size of the recipient site but may be for other reasons e.g. correction of centre lines or Class 2 division 1 cases.
- Best time for transplant: the timing of transplantation is important to minimize further endodontic treatment of the donor tooth and maximize periodontal healing. Data from a long-term study of 118 immature autotransplanted premolars with a 1–13 year follow,[37,42] showed the optimal outcome was where three quarters to complete root length of the graft tooth had occurred with an open apex of greater than 1 mm diameter. The study reported a 96% pulp regeneration rate.[42] In addition replacement resorption, i.e. failure of the periodontal ligament healing, was more prevalent in donor teeth with complete root development. This may have been as a result of the greater force employed to remove the graft tooth and subsequent damage to the periodontium. It is important to note, however, that mature closed apex teeth can be autotransplanted with good success provided appropriate endodontic therapy of the non-vital pulp canal is instigated within two weeks post-transplantation[43] to prevent inflammatory root resorption following pulp necrosis.
- Surgery: this needs to be carried out by an experienced autotransplant surgeon[44] who is gentle with the donor tooth both in its extraction but also with regard to generation of and placement in the recipient site. Where possible the donor tooth should be rotated by 90° to improve the emergence profile of the tooth for the later definitive crown build up phase.
- Transplant position and splinting duration: there is continued debate over the position the autotransplant should be placed in the donor site. Zachrisson *et al.*[45] suggested avoiding occlusal interference to transplanted donor teeth for two months post-surgery but recommended a degree of physiological mobility is maintained during the fixation period, recognizing that a prolonged period of rigid splinting may lead to ankylosis. Others argue that physiological movement should be encouraged and may promote favourable healing.[46,47] Duration of splinting should be 7–10 days, and the type of splinting should be similar to that advised for avulsed and replanted teeth.[15,16]
- Composite crown build-up: for aesthetic and psychological reasons the premolar needs to be built up as soon as possible. This can be done as early as 7–10 days. Prior to orthodontics the approximate size and shape of the crown needs to be established to ensure that this space is available at the completion of orthodontics.
- Endodontics: as previously noted, endodontics should be undertaken for a closed apex donor tooth at 7–14 days following transplantation. Even in an open apex case, careful monitoring of the tooth is required to diagnose pulpal infection prior to destructive inflammatory resorption occurring. At the these regular review intervals post-surgery (i.e. 1, 2, 3, 6, 12 months and then annually)[43] the transplanted tooth should be assessed clinically and radiographically for pulpal and periodontal healing as previously discussed in Part 1.[20]
- Orthodontic timing of treatment: Tsukiboshi[43] recommend starting orthodontic tooth movement after periodontal ligament healing (at about eight weeks) but before complete alveolar bone healing and stated extrusive orthodontic movement can be commenced one month after the procedure. This advice should be received with some caution however, as orthodontic movement will generate further inflammatory stimuli to the healing of the protective layer following transplantation. Treatment regimens in autotransplanted teeth, as in replanted avulsed teeth should be aimed at minimizing inflammatory stimuli until the complete healing of the periodontal ligament and cementum has finished.[48]

The orthodontist should retain a high index of suspicion that replacement resorption is occurring in an autotransplanted tooth that fails to move during orthodontic tooth movement. A summary of observation periods prior to orthodontic movement of transplanted and traumatized teeth to correct malpositioned transplanted teeth or problems of vertical bony defects around transplanted teeth can be seen in Table 1 in Part 1.[20]

- Definitive composite build-up: finally a definitive composite crown is provided to maximize the aesthetics. Czochrowska [49] examined the gingival and periodontal conditions around 45 restored premolars transplanted to the maxillary incisor region in a group of 40 adolescents (mean age 11 years) after a mean observation period of four years. No significant differences in gingival and periodontal parameters compared to the natural incisors of these patients were found, although slightly increased mobility and plaque retention was noted around a small number of restored transplanted premolars.

As has been alluded to above, the advantages and disadvantages of autotransplants are real and require a continuing dialogue between different members of the

team through the various treatment phases to maximize the aesthetic and biological result.

Partial denture

A simple acrylic denture to replace a missing anterior tooth is frequently used in the paediatric population. The recommended design is a T-shaped denture with clearance of acrylic from all gingival margins and Adams cribs on first permanent molar teeth to enhance retention. They are quick and simple to make and modify and can be used in both the short (e.g. while adjacent injured teeth heal prior to the construction of a resin retained bridge) and medium term (e.g. where few other treatment options exist) until anterior alveolar growth has completed and implants may become applicable. Partial dentures do have a number of associated problems including denture induced stomatitis and dental caries where plaque control and denture hygiene is poor. Tissue borne dentures may well have a further detrimental effect on bone volume in the anterior area.[50] For most adolescents, however, having no prosthetic replacement is unacceptable. Consequently, despite some of their limitations tissue borne partial dentures are still frequently used when teeth have been extracted or replantation of an avulsed tooth is contra-indicated.

Resin bonded bridge

The option of resin-bonded bridgework (RBB) is a well-accepted technique to replace missing teeth and has been available as a treatment modality for almost three decades. In the adolescent the use of a RBB can provide an aesthetic solution to replace a maxillary incisor tooth in a situation where there is good bone and soft tissue contour and abutment teeth have a good prognosis. The occlusion must be assessed to ensure minimal or no contact of the pontic in excursive movements. This is an important consideration if orthodontics is undertaken prior to RBB. Resin-bonded bridgeworks are frequently a more attractive and comfortable option than a partial denture and cause less detrimental effects to the supporting tissues.

It was not possible to identify any studies investigating the success of these restorations solely in an adolescent population. A meta-analysis investigating the longevity of RBBs[51] for adults, indicated an overall survival of 74% at 4 years for all RBBs placed. The type of retention and the location of the bridge were analysed separately, weighted multiple-regression analysis of these factors revealing no detectable influence of either factor on ultimate survival. It should be noted that extensive buccal bone loss (as a result of original trauma or subsequent extraction) increases the complexity of providing an acceptable aesthetic result. Although this may not prove to be a definitive restorative solution, if it provides good aesthetics with minimal or no preparation of the adjacent tooth then it achieves the aim of enabling the adolescent to reach adulthood with all treatment options still open.

Implant

Only once growth has ceased can osseo-integrated implants be provided. Every effort should have been made to maintain bone in the site of the missing anterior tooth e.g. retention of root for group 1 cases and decoronation for group 3 cases to allow the child to reach adulthood with all treatment options available. Despite this, surgical bony augmentation may still be required. A more detailed discussion of osseo-integrated implants for replacing missing anterior teeth following trauma is outside the scope of this article.

Summary

This second paper has examined the evidence to support the management for poor prognosis traumatized anterior teeth and the treatment options available for the subsequent space when the tooth or teeth is lost or extracted in a growing child.

Conclusions

- The team management of failing, traumatized anterior teeth in children requires an interdisciplinary approach to maximize the treatment options available. The team should include specialists in orthodontics, paediatric dentistry and sometimes may require the input of oral and maxillofacial surgeons and restorative dentists. The provision of restorative treatment within the plan may be provided by either the paediatric dentist or general dental practitioner.
- Group 1. Teeth that have undergone apexification techniques have brittle thin walls that may fracture under normal physiological stress, further trauma or during or after orthodontic treatment. Frequently, following crown/root fracture or cervical third root fractures the remaining root is retained with appropriate endodontic intervention while the space left by the loss of the coronal fragment is restored.
- Group 2. Teeth with persistent infections (despite best endodontic endeavours) require prompt extraction to prevent symptoms and further loss of alveolar bone.

An atraumatic extraction is required to preserve remaining bone. The subsequent space must then be restored.

- Group 3. All efforts should be made to replant avulsed teeth within 60 minutes following avulsion. This includes encouraging bystanders and parents to do so if contacted by telephone. After 60 minutes ankylosis is almost always guaranteed and therefore replantation after this time should be considered a temporary/intermediary tooth replacement. Teeth should be still be replanted and then rapidly referred to the interdisciplinary team for further management.
- Group 3. The aim of treatment for the ankylosed permanent incisor should be to maintain the tooth for as long as possible to preserve dentoalveolar bone and allow a full range of restorative treatment options to be considered. Where ankylosis is detected before ten years of age or in cases of severe infra-occlusion, aesthetics and restorative options are significantly compromised. An atraumatic extraction or decoronation is indicated, the timing of which may be delayed to coincide with the optimal time for an autotransplant.
- All groups. The management of the subsequent space following tooth or crown loss in a growing patient includes replacement with a denture, resin-bonded bridge, orthodontic space closure or re-opening (bone generation) or tooth autotransplant and should take into account the patient's oral hygiene, occlusion and compliance.
- All groups. Autotransplantation is frequently the best treatment option (where feasible) due to its ability to induce and maintain bone, move under orthodontic forces and survive, where successful, as long as any uninjured adjacent tooth.

All these options should be considered and be available as appropriate to an interdisciplinary team to ensure optimal care of children with anterior teeth of poor prognosis.

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