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Orthodontic Extrusion: An Interdisciplinary Approach to Patient Management

Abstract: Root fractures that occur at the cervical margin do not always heal predictably, even following a period of splinting. This often leaves margins either sub-gingival or sub-crestal. This provides an unsatisfactory situation for restoring the remaining root as restorations will impinge on the biological width. Provided a root is long enough to support a post crown, then orthodontic extrusion to provide sufficient supra-gingival tooth tissue is a useful treatment option to consider. A review of the literature on orthodontic extrusion is considered in conjunction with a case report of the management of a young male who fractured a canine and lateral incisor whilst playing cricket.

Clinical Relevance: Trauma to upper anterior teeth is frequently seen in practice. One treatment option in the management of sub-crestal cervical root fractures is orthodontic extrusion, rather than removal of the tooth.

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Intra-alveolar root fractures in the cervical region are relatively uncommon.^{1–3} In the past, the long term prognosis was considered to be poor. It was thought that a short mobile coronal fragment had a lower probability of healing, and that there was a possibility of bacterial contamination of necrotic pulp tissue from the gingival crevice.^{4,5} However, this assumption has not been supported by recent literature. No relationship between frequency of pulp necrosis and the position of the fracture line has been demonstrated.⁵

The duration of splinting does

not seem to be significant, with 4 weeks being considered an appropriate time scale.⁶ Factors that can negatively influence healing include mobility of the coronal fragment, dislocation of the coronal fragment and rupture or stretching of the pulp at the fracture site (diastasis).⁵ Cvek *et al*,⁴ in a study of 94 cervical root fractures, found that the frequency of healing of transverse fractures was found to be the same as oblique fractures. Despite healing in cases with transverse cervical fractures, even a minor impact can cause a breakdown of the healed site and increased mobility.⁴

Orthodontic extrusion of a root fractured tooth in the coronal third was first described by Heithersay in 1973.⁷ Various techniques for the vertical movement of a fractured root have been described. These include both removable and fixed orthodontic appliances.⁸ Orthodontic extrusion has also been indicated for the management of:

- Isolated osseous defects;⁹
- External or internal resorptions;¹⁰
- Iatrogenic perforations;¹⁰
- Slow extraction of teeth where routine

extractions are contra-indicated because of radiation therapy.¹⁰

The principal aim of orthodontically extruding a fractured tooth, so that it can be restored, is to provide a supra-gingival tooth margin. This will enable provision of an extracoronal restoration that will not impinge on the periodontium. The following case report describes the application of fixed appliance therapy to extrude two adjacent fractured teeth, and their ultimate restoration.

Case report

A 21-year-old male patient was referred by his general dental practitioner for the management of his mobile upper right lateral incisor and canine. A year previously he had taken a blow to his face with a cricket ball whilst practising in the cricket nets. The patient's only concern was that the teeth were still mobile following the accident. His lacerated lip was dealt with by the local accident and emergency department at the time of the accident.

On examination, it was noted

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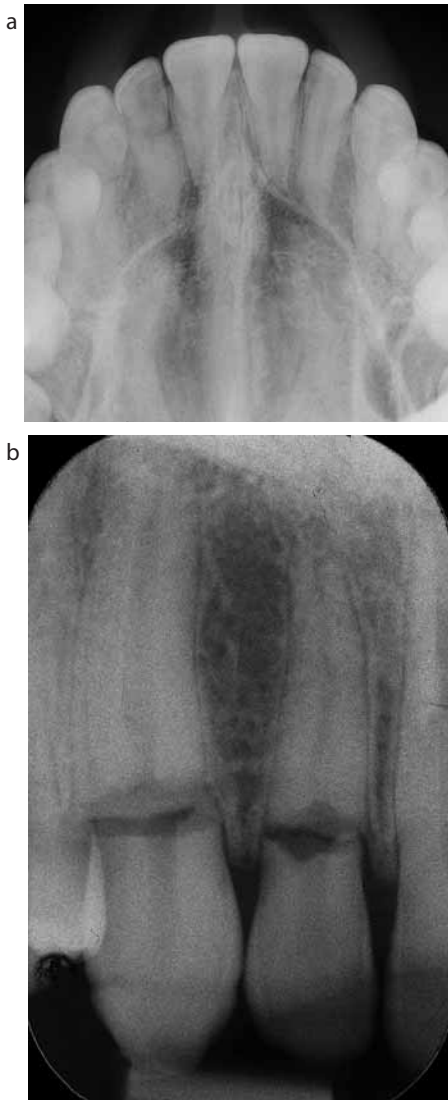


Figure 1. (a, b) Radiographs showing sub-crestal fractures of the UR2 and UR3.

that the UR2 was Grade II mobile and the UR3 was Grade I mobile. Vitality testing was negative for the lateral incisor and positive for the canine. The patient had an otherwise intact dentition which was minimally restored. Periapical radiographs were taken of UR4,3,2,1 and UL1 plus an upper anterior occlusal view to identify or discount root fractures more clearly (Figure 1). The radiographic examination confirmed the presence of fractures to both the right canine and lateral incisor roots. Both these fractures were horizontal and sub-crestal; approximately 2 mm. There was some displacement at both fracture sites and a general widening of the periodontal



Figure 2. Patient with immediate partial denture *in situ*.



Figure 3. Gold cast posts with islets for engaging the orthodontic wire for extrusion.

ligament spaces above the fracture lines. Mesially on the canine there was evidence of a very small semicircular area of resorption adjacent to the fracture site. There had been resorption of the lateral incisor at the fracture site in both the crown and root portions. There was no evidence of damage to the adjacent teeth. There was also evidence of widening of the apical periodontal ligament space on the UR2.

A number of treatment options were discussed with the patient and these included:

- Extraction of the teeth and provision of resin-retained bridgework;
- Surgical crown lengthening and post crowns;
- Dental implants;
- Orthodontic extrusion and provision of post crowns.

The decision taken was to extrude the teeth orthodontically and provide post crowns. Prior to extrusion, the teeth were root-filled. Initially, an attempt was made to complete this phase of the treatment through the coronal fragments of the teeth. This proved impractical, probably owing to the displacement of the fragments and fibrous healing tissue between the two segments. The teeth were therefore decoronated and the root canal systems were prepared with the Profile® (Dentsply)



Figure 4. (a) Radiographic evidence of orthodontic extrusion. **(b)** Gingival position pre-orthodontics. **(c)** Gingival position post-orthodontics.

NiTi rotary system and obturated with gutta-percha using a cold lateral condensation technique and Tubiseal™ EWT (Kerr® Corporation USA). The patient was provided with an immediate replacement denture following decoronation of the teeth (Figure 2). Post preparation was completed using the Para-post® (Coltène/Whaledent Inc) castable post technique. The posts were designed with eyelets to engage the orthodontic wire (Figure 3) and were cemented with Poly-F® (Dentsply, DeTrey GmbH).

Orthodontic bonds were placed

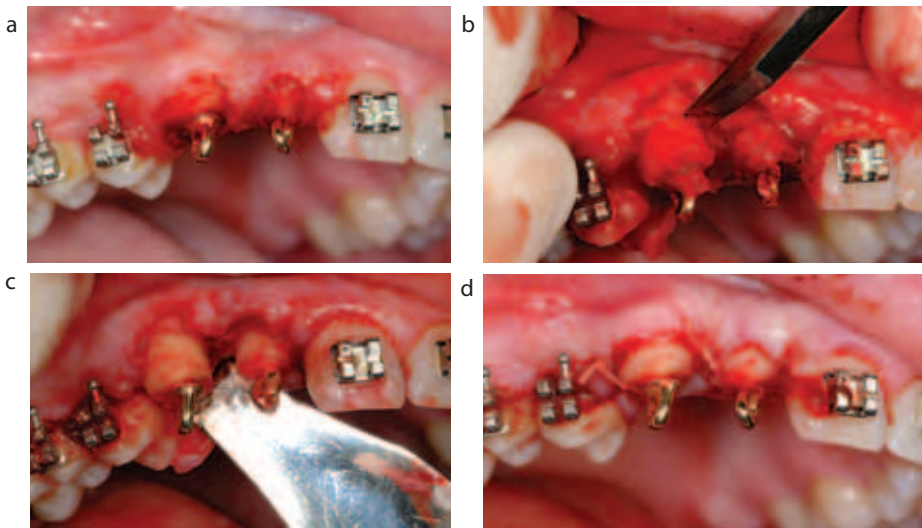


Figure 5. (a–d) Gingival surgery and osseous recontouring.



Figure 6. One week post gingival surgery.



Figure 7. Buccal tipping of the UR3 following orthodontic extrusion.

on the UR6 to UR4 and UL1 to UL6. Levelling and aligning of the arches were completed with a 0.014 NiTi upper archwire followed by a 0.018 NiTi archwire. A 0.018 SS upper archwire with an elastic thread applied from the post eyelets to the wire was used to extrude the teeth. The mechanics were repeated over 4 months to provide the extrusive force. Clinical and radiographic assessment established that sufficient extrusion had occurred for the next phase of treatment to proceed (Figure 4).

Proliferation of gingival tissue

occurred during extrusion and thus gingival recontouring was required. This was completed in conjunction with a small amount of osseous recontouring to provide sufficient supra-gingival tooth tissue to enable a ferrule of at least 1.5mm to be produced (Figure 5). The gingivae were first recontoured to the level of the contra-lateral lateral incisor and canine and then buccal and palatal flaps were raised with no relieving incisions. Selected bone removal was completed to create the correct contour and to provide 5 mm between the bone margin and the teeth edge. This was completed with a combination of chisels, burs and an ultrasonic. Three 3.0 Vicryl® (Ethicon) sutures were placed and Coe-pak™ (GC America) was applied to the surgical site. The appliance was replaced immediately after the surgery and the patient was reviewed a week later (Figure 6).

It was noted, post surgery, that the orthodontic treatment had led to buccal tipping of the UR3 root (Figure 7) and therefore a new 0.016SS wire was bent with a second order bend to engage the gold posts and a first order bend to engage the canine. Following sufficient palatal movement, the posts were easily decemented and the teeth were re-root treated prior to preparation of the definitive post and cores. This re-root treatment was deemed appropriate owing to the sub-crestal position in which the primary root treatment was completed, not providing ideal conditions for good isolation from bacterial contamination. Following this, post

preparation was completed using the Parapost® casting technique and a 2 mm ferrule was produced on the root face. Definitive post and cores were cemented with Poly-F. The orthodontic appliance was removed and provisional composite crowns were cemented with Temp-bond (Kerr®, Switzerland). Prolonged retention was provided with a Stick Tech® (Stick-Tech, Finland) splint bonded labially from the UR1 to the UR4 for a further three months (Figure 8).

Definitive porcelain fused to metal crowns were cemented with Poly-F and were designed with a palatal groove for a twist-flex palatal retainer, which was bonded to the crowns and the UR1 and UR4 (Figure 9). The patient was also provided with a sports guard. On review a year later, the restorations were satisfactory and there was no evidence of apical pathology on the radiographs.

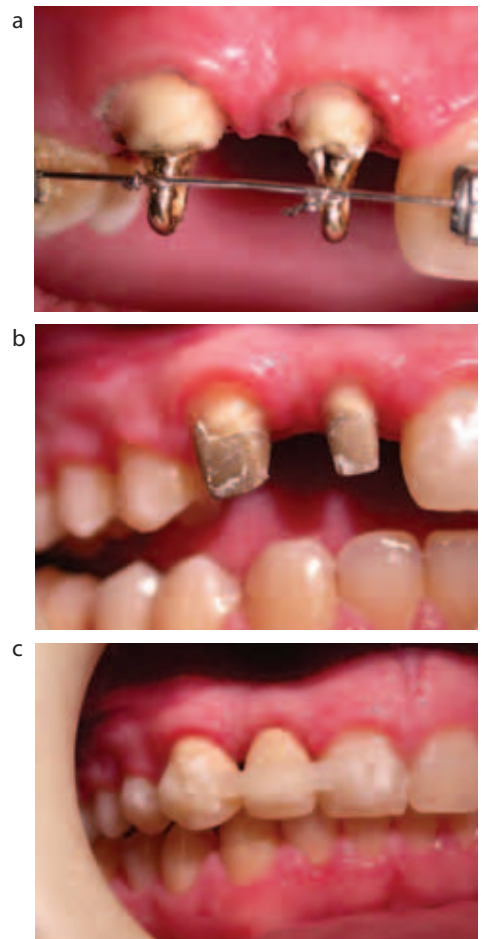


Figure 8. (a–c) Post preparation with ferrule and provisional composite crowns with Stick-Tech splint *in situ*.

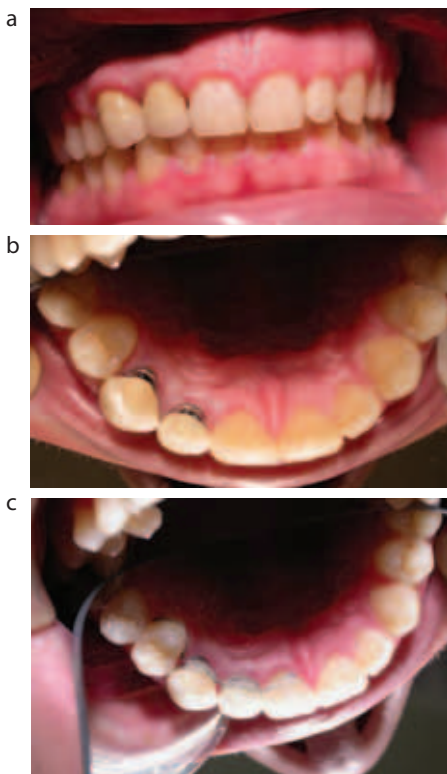


Figure 9. (a–c) Definitive crowns with permanent palatal twist-flex retainer *in situ*; **(b)** shows the groove cut into the crown for the twist-flex wire.

Discussion

When planning orthodontic extrusion it is important to consider:

- The ultimate position of the teeth being extruded;
- The implication of gingival margin position;
- Providing appropriate anchorage;
- Carefully planned orthodontic forces;
- The prevention of post-operative complications.

Simplified techniques have been described using localized fixed appliance systems to extrude fractured teeth. A common problem with these simplified techniques is that, as the fractured tooth is extruded, the 'anchor teeth' become intruded to a much greater extent. To eliminate this effect completely, a removable appliance that uses the palate as its source of anchorage could be considered.⁸

When the technique of orthodontic extrusion was initially used it was thought that forces less than the 0.25N–0.4 N required to move teeth orthodontically would be sufficient.

Measurements taken with appropriate spring gauges demonstrated that ideal extrusive forces are variable, but usually within the range of 0.7N–1.5 N.¹² Rapid extrusion is associated with a risk that the periodontal ligament could be torn during the process, leading to ankylosis of the tooth. The application of too great a force, if uncontrolled, could also lead to pathologic resorption.¹¹

Teeth of unfavourable prognosis, where an implant is to be used to replace the missing unit(s), can sometimes be orthodontically extruded to benefit the implant site.¹² This technique can be used to regenerate bony defects, providing an appropriate volume of bone for implant placement. It is recommended that, following the phase of extrusion, a period of 4–6 months is left for stabilization and maturation of the newly formed bone before implant placement.¹³

Another consequence of extrusion is the coronal shift of the marginal gingiva. The shift includes a proliferation of the gingival tissue and is not related to coronal displacement of the gingiva.^{11,14} Initially, eversion of the sulcus epithelium occurs. This first appears as immature non-keratinized tissue described as 'the red patch'. Subsequently, keratinization occurs, taking between 28–42 days. This proliferation of tissue can be an advantage for implant purposes, as the newly keratinized tissue can improve the aesthetic outcome of the final restoration.¹³ In order to prevent this occurrence, a gingival fibreotomy immediately before the extrusion has been shown to allow the tooth to extrude without bringing the gingiva with it.¹⁵ Pontoriero *et al*,¹⁶ however, recommended weekly fibreotomies for 3 weeks. This was intended to decrease tension from crestal fibres and prevent osteoid formation so that post-operative surgical crown lengthening would not be required.

In cases of extrusion, the final gingival margin position and contour can be unpredictable. In these circumstances, some minor recontouring is often required. In the case presented, a gingivectomy was required to expose the extruded root surface. Despite the radiograph suggesting that sufficient extrusion had occurred, some minor bony recontouring was required to prevent the likelihood of gingival re-growth occurring as the biological width re-established.^{17,18} A

minimum of 1.5 mm of supra-gingival tissue was desirable to enable a suitable ferrule to be achieved, as this is considered an appropriate amount to reduce the risk of root fracture with post-retained crowns.^{19,20}

The rapid extrusion of teeth involves stretching and re-adjustment of periodontal fibres, without marked bony remodelling due to the rapid movement. It can thus be achieved without a coronal shift of the marginal bone.²¹ Relapse is possible following orthodontic extrusion, primarily because of the stretched state of the marginal periodontal fibres. Fibreotomy, both before and immediately after the extrusion, has been recommended as a technique to minimize the risk of relapse.²²

Whilst many case studies have reported on various techniques for orthodontic extrusion, only one has examined the relapse tendency and extent of root resorption.²² In that study, a relapse of 0.5mm was seen in less than 10% of cases. One of the 33 teeth developed severe resorption, and six teeth showed limited resorption, but did not progress in the following two years of observation. The authors concluded that relapse was possible but, with a fibreotomy and a period of retention of at least 3–4 weeks, this would adequately reduce the risk. They also concluded that permanent retention was not advised and root resorption, as a consequence of rapid orthodontic extrusion, is rare. There are conflicting reports in the literature on the suitable time period for retention to prevent relapse occurring. Whilst the above study recommended 3–4 weeks,²² others have suggested a stabilization period of 7–14 weeks.²³ Another protocol suggested was one month per mm of extrusion,²⁴ whilst Minsk had suggested four months for every mm of extrusion.¹¹

In the case presented, the orthodontic movement resulted in displacement of the roots buccally. This is because the brackets on the adjacent anchor teeth and the wires used were positioned more buccally than the roots being extruded. This could have been avoided if the islet had been designed at 90° to the position used. Alternatively, compensatory wire bends could have been produced to prevent the problem.

The natural conical shape of anterior roots means that, as they are extruded, their mesio-distal width reduces. The gingival embrasure dimensions will

therefore increase. This is one disadvantage of this technique for the patient with high aesthetic demands. Care needs to be given to the crown design so that it is not overcontoured, as it may have adverse effects on the periodontium. It has been shown that a well contoured crown producing a contact point 5 mm above the bony crest will result in papillary infill of the embrasure space in 98% of occasions.²⁵ With the gingival embrasure dimensions increasing (as already discussed), the likelihood of papillary infill reduces. A study by Cho *et al*²⁶ showed that interdental papillae were present in 78% of cases when the interproximal distance of roots was 1mm, but the papilla was always lost when the interproximal distance was equal to or greater than 4 mm. This is important to consider when discussing this treatment option with a patient with a high aesthetic demand and/or a high lip line.

The patient was provided with provisional crowns for a period of 6 months to enable stabilization of the gingival margin position to occur. Studies have identified that, following crown lengthening procedures, the gingival margin can take time to stabilize and is influenced by its biotype.^{18,27}

Conclusions

This paper has presented a case of two teeth with root fractures that were retained with combined orthodontic extrusion, surgical crown lengthening and fixed prosthodontic restorations.

Treatment of this nature is relatively complex. It relies on the close liaison of both an orthodontist and a restorative dentist who can manage the restoration of the teeth and the supporting tissue. It is important that all dentists are aware of this possibility before extracting sub-crestally fractured teeth as they could potentially be restored.

As the implant treatment option continues to grow in terms of availability and success rates, orthodontic extrusion of fractured teeth may lose favour. In the meantime, however, there may be circumstances where implants are inappropriate. These include, the young age group, the medically compromised or where patients would prefer to keep their own teeth. In these cases, orthodontic extrusion may be appropriate not only to develop the gingival and osseous architecture prior to implants, but also as part of a definitive treatment plan.

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