Enhanced CPD DO C

Harman Kaur

Ayla Mahmud and Mital Patel

Long-term Retention of Severely Traumatized Teeth. Part 2: Retention of a Root-fractured Tooth for 8 years after Injury

Abstract: Part 1 of this two-part series discussed the key principles in decision-making when managing severe dental trauma. This second part demonstrates the application of these principles through a complex trauma case that was restoratively managed to preserve the traumatized dentition. In this case study, the management of a young patient who incurred extensive traumatic dental injuries to his maxillary incisors, including root fracture in the mid third of the UR1 and luxation injuries to the UL1 and UL2, is explored. The teeth were retained at 8 years' post-operative follow-up.

CPD/Clinical Relevance: Correct acute and timely management of severely traumatized teeth can allow the teeth to be retained for a prolonged time.

Dent Update 2026; 53: 76–82

Traumatic dental injuries are common across the population. They can have long-term implications for the affected individuals and are a major public health problem. Luxation injuries, which are the most common and complex form of traumatic dental injury, include avulsions, lateral displacements and intrusion of teeth.[1] Root fractures are another complex form of traumatic injury, and are often challenging to manage owing to the varied locations and associated prognosis.

Root fractures are defined as a fracture of a tooth that involves the dentine, cementum and pulp.[2] They may occur in any direction or orientation and are typically classified as vertical fractures (usually also involving the crown) or transverse (often called horizontal or oblique) root fractures. They are further classified according to whether the fracture is located in the apical, middle or coronal third of the tooth root.[3] Fractures nearer the cervical region are often particularly complex, owing to

Figure 1. Extra-oral image taken by the patient shortly after the trauma occurred. The image shows the severely palatally displaced UL1, UL2 and UR1 teeth.

Harman Kaur, BDS, MFDS RCSEd, Speciality Training Registrar in Restorative Dentistry, University College London Hospitals NHS Foundation Trust. **Ayla Mahmud**, BDS, BSc(Hons), MFDS RCSEd, Speciality Training Registrar in Restorative Dentistry, Barts and The London Hospital Trust. **Mital Patel**, BDS, BSc(Hons), MFDS RCS(Eng), MSc, FDS (Rest Dent) RCS(Eng), FDS RCS (Ed), Consultant in Restorative Dentistry and Honorary Senior Clinical Lecturer, Barts and The London Hospital Trust.
email: harman.kaur@nhs.net

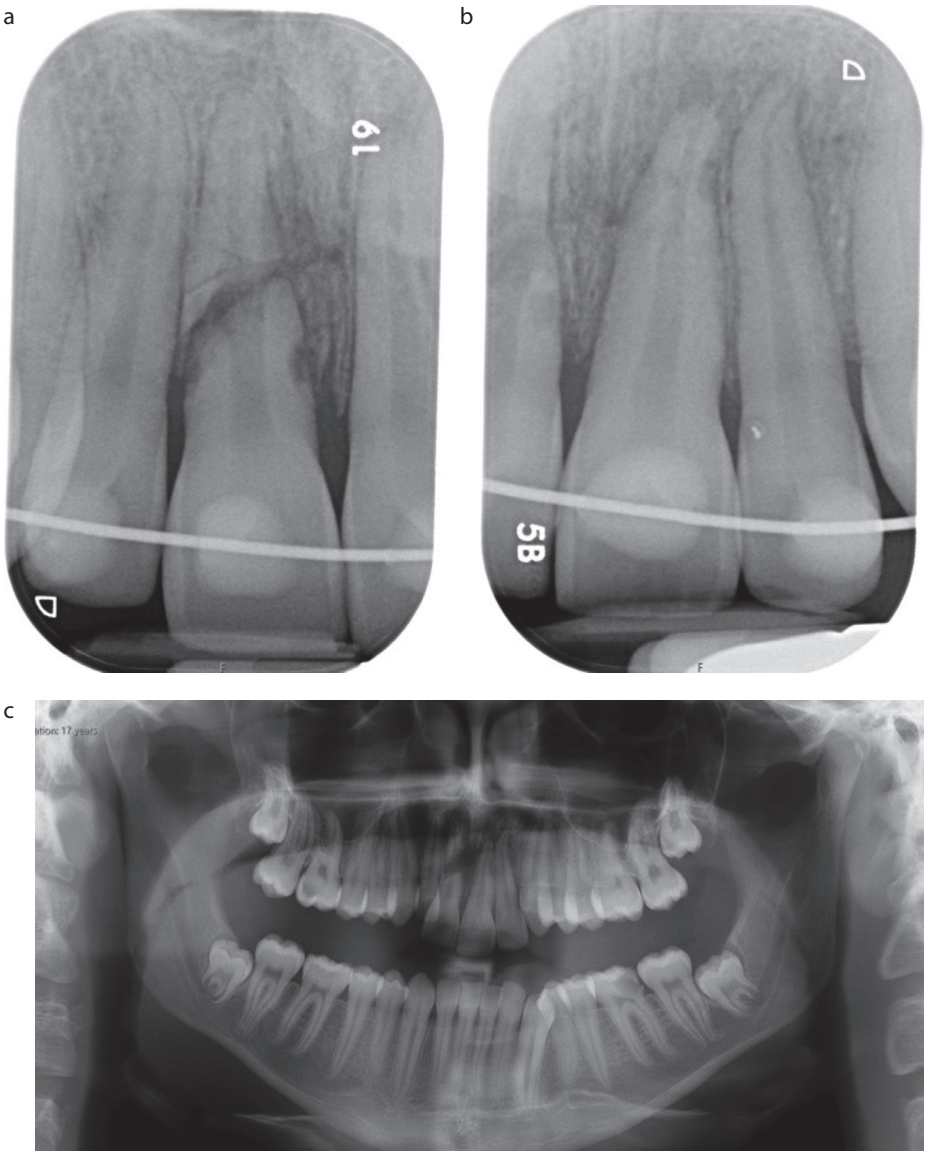


Figure 2. (a) Orthopantomogram and **(b,c)** peri-apical radiographs of the UR1, UL1 and UL2 taken at initial assessment.

difficulties in stabilizing the coronal fragment and the risk of infection or pulp necrosis, resulting in a worse prognosis. Root fractures may occur concurrently with another dental injury to the same tooth, the most common concurrent injuries being concussion and luxation injuries. This further complicates management and prognosis.[3]

Understanding the biology behind an injury is important to determine the correct management. Each of these injuries can result in a crushing and/or separation injury to the periodontal ligament (PDL). This type of injury is most often associated with intrusion and severe lateral luxation injuries. Owing to extensive damage to the PDL cells, intrusion and lateral luxation injuries take longer to heal and result in more severe long-term complications. This form of injury, especially in cases of severe displacement, can disrupt the vasculature of the pulp and lead to pulp necrosis.[4]

Further significant consequences of luxation injuries to the teeth include root surface resorption, which can be inflammatory resorption, replacement resorption, or a combination of both.[5] Separation injuries of the PDL often associated with extrusions or avulsions result in less damage to the PDL cells and therefore heal more quickly. Further details on luxation injuries are discussed in Part 1 of this series. In this second part, a case that focuses on root fractures and their management complexities is presented.

Timely management and close monitoring of these cases is vital to achieving successful outcomes and dealing with complications when they arise. When managing these complex cases, a multidisciplinary approach is important for preserving the bone and creating space for endodontic and prosthodontic treatment. The aim of the initial and long-term management of such traumatic dental injuries is to preserve the tooth structure, prevent tooth loss and restore the aesthetics and function of the patient's dentition.[6] Preservation of tooth structure consequently enables preservation of bone and soft tissues around the traumatized teeth. This minimizes the long-term sequelae of the traumatic incident and maintains structures for implant rehabilitation in the event of tooth loss.[7,8]

Case report

A 17-year-old patient attended an accident and emergency department with a root fracture and palatal luxation of the fractured coronal portion of the UR1 and severe luxation of the UL1 and UL2 following a boxing injury. The coronal portions of the UR1, UL1 and UL2 were all palatally displaced, resulting in a severe crushing injury to the PDL on the palatal side and a separation injury to the labial side (Figure 1). No dento-alveolar fractures were sustained. Medically, the patient had mild asthma, managed with a Ventolin inhaler.

An orthopantogram and peri-apical radiographs revealed an oblique root fracture of the UR1 at the mid-third level (Figure 2). The UL1 and UL2 roots appeared sound. Acute management involved repositioning the teeth and stabilization with a flexible splint for 6 weeks. The splinting time was extended because of the position of the root fracture at UR1.

As per the International Association of Dental Traumatology guidelines, the patient was clinically and radiographically monitored at regular intervals.[9] At 4 months post trauma, the UR1 showed evidence of pulpal necrosis and radiographic evidence of external root resorption. The UL1 and UL2 remained radiographically sound (Figure 3).

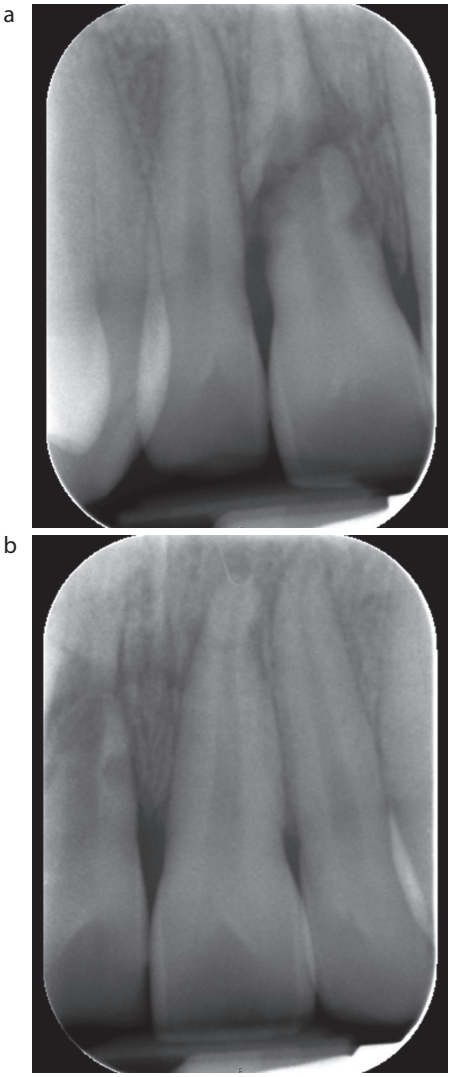


Figure 3. (a,b) Peri-apical radiographs of the UR1, UR2, UL1 and UL2 taken at a review appointment 4 weeks after the traumatic injury, showed external root resorption of the UR1. The UL1 and UL2 appeared radiographically sound.

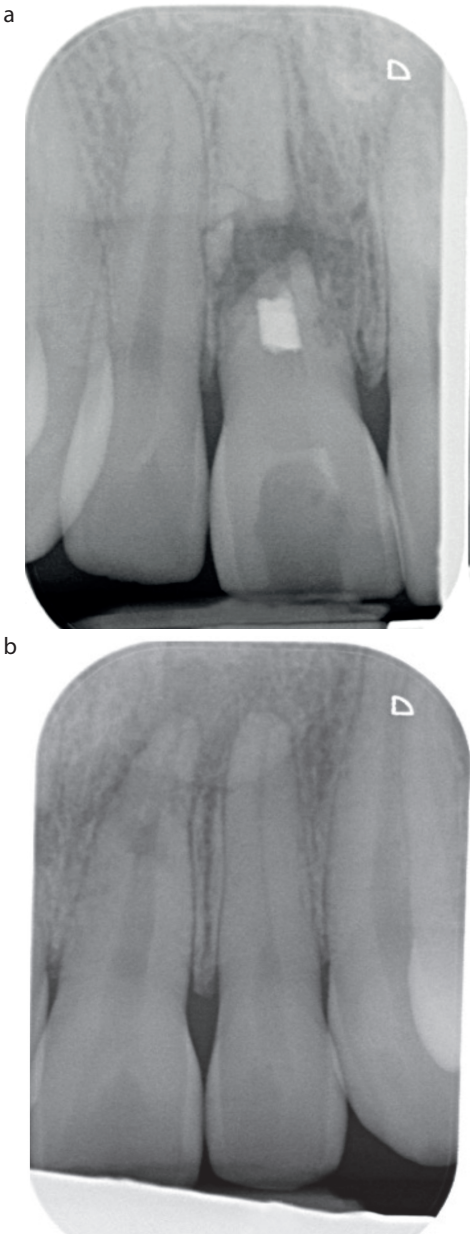


Figure 4. Radiographs 3 years post trauma in 2018. **(a)** Peri-apical radiograph of the UR1 and UR2 taken in February 2018. **(b)** Peri-apical radiograph of the UL1 and UL2 taken in February 2018. **(c–f)** Sectional views from a CBCT scan taken in July 2018. **(c)** Cross-sectional view of the UR1, showing UR1 root fracture, resorption between the two fragments with non-union and an apical restoration in the in coronal fragment. It shows intact labial and palatal bone despite the extensive trauma. **(d)** Cross-sectional view of the UL1. This shows thin labial bone plate and good palatal bone, resorption in the mid-root on the labial aspect of the root surface and fenestration into the pulp of the UL1 with intact buccal bone. A large peri-apical radiolucency is associated with the UL1. **(e)** Coronal view of the UR1 and UL1. This shows UR1 root-fractured fragments with resorption and non-union, and the presence of an apical plug restoration in the coronal fragment. The UL1 shows a large peri-apical pathology with resorption. Bone levels appear 2–3mm below the cemento-enamel junction. **(f)** Axial view of the UR1 and UL1 with signs of resorption.

Treatment options discussed included extraction of the UR1 with prosthetic tooth replacement, and endodontic treatment with the aim of retaining the UR1 for as long as possible. Given the patient's age, the decision was made to attempt to save the tooth and maximize its lifespan.

Endodontic treatment of the UR1 was carried out in the coronal portion to the fracture line, with a mineral trioxide aggregate (MTA) plug.[7] The apical portion remained in situ and was asymptomatic. As this portion of the tooth had not been displaced, the assumption was that the blood supply to the apical portion was sustained, with only the coronal portion having lost vitality. The UL1 and UL2

Figure 5. Intra-oral clinical photograph taken in 2018, demonstrating the clinical appearance of the UL1 and UR1 teeth.

responded variably to sensibility testing and were kept under close clinical review.

It was agreed with the patient to continue regular reviews of the traumatized teeth, which had a guarded prognosis, and consider prosthetic tooth replacement of the UR1 with a dental implant once he turned 18 years of age.

The patient remained asymptomatic and stable throughout review appointments for 2 years. However, radiographs taken 3 years post trauma showed evidence of resorption at UL1 (Figure 4). A cone beam CT (CBCT) scan taken to investigate the extent of resorption showed an apical radiolucency associated with the UL1 with resorption, resulting in a labial fenestration in the mid to apical third of the root (Figure 4). A radiolucency between the coronal and apical portion of the UR1 was also noted. Initially, this was thought to be present as a result of resorption secondary to a root fracture, but further analysis showed an intact labial plate and a difference in the position of the UR1 and UL1 roots. Figure 4c shows that the apex of UR1 was more apical to that of UL1. While there was probably an element of inflammatory resorption, this seemed to have settled after initial endodontic intervention and placement of the MTA plug. It was likely that the coronal portion continued to erupt as the patient grew, which brought the labial bone down with it. This resulted in a gap (appearing as radiolucency) developing between the coronal and apical potions, which was most likely filled with fibrous tissue. The apical portion of UR1 did not appear to have moved as growth progressed because it had lost its eruptive potential.

A diagnosis of chronic apical periodontitis and external root resorption of UL1 was made. No signs of infection or loss of vitality were noted in the UL2. With regards to the UR1, the diagnosis made

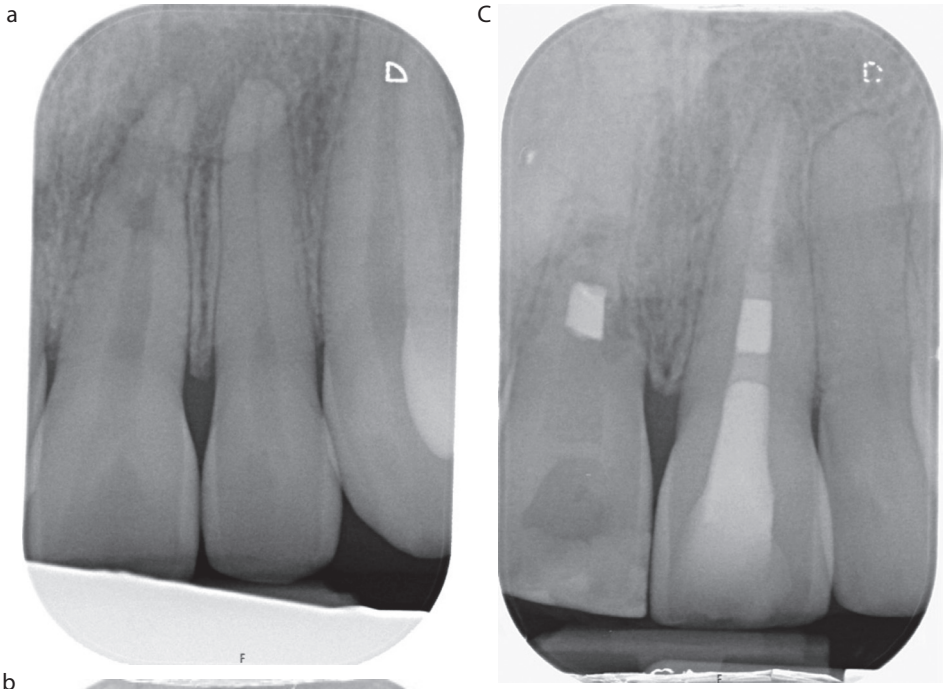


Figure 6. Root canal treatment completed on the UL1. **(a)** Pre-operative radiograph of the UL1 showing radiographic evidence of internal resorption. **(b)** Mid root-canal treatment radiograph showing gutta percha cut back. **(c)** Post-operative radiograph.

included mid-third root fracture with separation of the coronal and apical fragments owing to continued growth and development. The apical portion showed pulp canal obliteration, which suggested retained vitality, although the coronal portion had lost vitality.

Treatment options and the poor long-term prognosis of the UR1 and UL1 were discussed in detail. The options included: maintenance of the UR1 and UL1 with orthograde endodontic treatment of the UL1 or extraction of the UR1 with or without the UL1 followed by prosthetic replacement of the teeth with an implant-retained restoration, a resin-retained bridge or a partially removable denture.

Despite all the above radiographic findings, clinically there were no signs of inflammation or infection associated with these teeth. The pink and white aesthetics of the teeth appeared near ideal with the tooth position and zenith levels appearing highly aesthetic (Figure 5).

In the absence of any symptoms, signs of infection or increased tooth mobility along with the presence of excellent aesthetics, it was decided to maintain the UR1 and carry out orthograde endodontic treatment of the UL1. While understanding the long-term prognosis, the patient was keen to retain his natural teeth for as long as possible. Given his young age, delaying extractions and the need for prosthetic replacement was also the preferred clinical choice. Endodontic treatment of the UL1 was arranged.

In the absence of communication with the labial bone, surgical intervention of the UL1 was deemed too destructive. Management aimed to treat the necrotic pulp and reduce the osteoclastic activity

at the resorption defect. Orthograde endodontic treatment of the UL1 was completed under a microscope. Figure 6a shows a pre-operative peri-apical radiograph, where a large apical radiolucency around the UL1 and internal resorption can be seen.

All visible soft granulation tissue originating from the resorption defect was removed from the canal. Irrigation was carried out with diluted sodium hypochlorite to prevent the risk of irrigant extrusion through the labial fenestration. MTA was packed into the canal to seal the apical portion and the perforation. A radiograph (Figure 6b) taken midfill shows the MTA was at the correct apical level and had no voids. Backfill was carried out with Obtura (Kerr, USA), and a glass ionomer cement seal was placed. A post-obturation radiograph (Figure 6c) of the UL1 shows a good root canal obturation.

After endodontic treatment had been completed, aesthetic improvements for the UR1 and UL1 were considered. As seen in Figure 5, the incisal edge of the UR1 appeared shorter than the UL1 and there was mild UL1 discolouration. The slight step between UR1 and UL1 may have been a result of ankylosis of the coronal portion of UR1, which would explain why it was so firm despite the root fracture and reduced crown:root ratio. It was opted to improve aesthetics with composite edge bonding of the UR1 to level and establish symmetry of the incisal edges. Figure 7 shows the aesthetic outcome following composite edge bonding of the UR1. The patient declined internal whitening following endodontic treatment of the UL1 because the mild discolouration did not concern him.

Radiographic reassessment of the UL1 was undertaken 1 year after endodontic treatment completion – 5 years since the initial trauma – which revealed healing of the peri-apical radiolucency surrounding the UL1 (Figure 8). An incidental finding of further external replacement resorption was noted of the UR1. There was still no increased mobility or sinus tracts associated with the UR1.

As the teeth remained clinically asymptomatic with stable aesthetics, it was decided to continue monitoring them. Figure 9 shows peri-apical radiographs taken 7 years after the initial trauma and 3 years following endodontic treatment of the UL1. The peri-apical radiographs show apical healing around the UL1, with relatively stable but considerable external resorption around the UR1. The patient was referred for an implant prosthesis assessment; however, the specialists advised continuing to maintain the dentition.

Eight years after trauma, the patient remained stable and asymptomatic with no sequelae and was content with the aesthetics of the UR1 and the planned retention and monitoring. Figure 10 shows images of the dentition. Aesthetically, the dentition was stable, with favourable positioning, alignment and appearance. Gingival health appears good, with minimal inflammation, knife-edge papilla and aesthetically proportionate gingival zenith positions. The UL1 appears to have discoloured further following endodontic treatment. Considering the patient's wishes and the risk of cervical resorption with internal

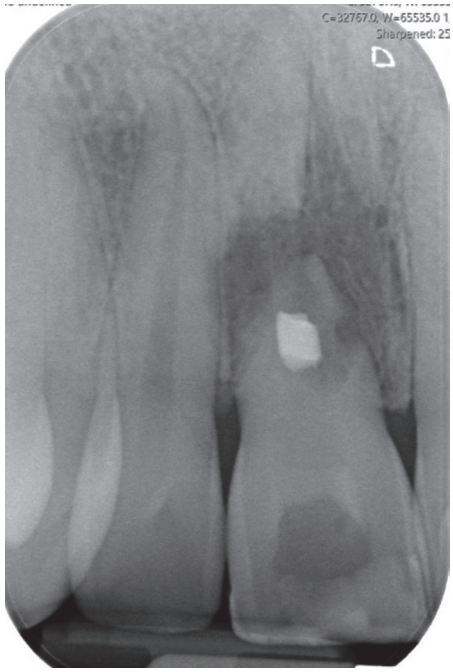
a

b

Figure 7. Intra- and extra-oral views of the UR1 and UL1 after endodontic treatment of the UL1 and composite restoration of the UR1. Photographs taken in 2019.

Figure 8. Peri-apical radiograph of the UL1 and UR1 year after endodontic treatment of the UL1. This shows healing of the apical radiolucency around the UL1 and external resorption of the UR1.

a



b

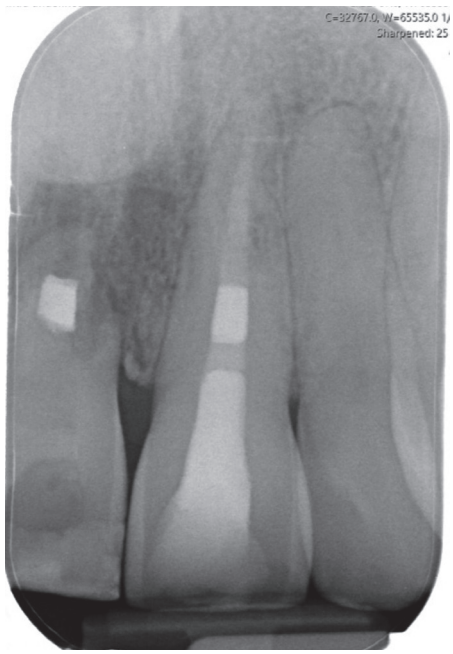


Figure 9. (a,b) Peri-apical radiographs 7 years after trauma.

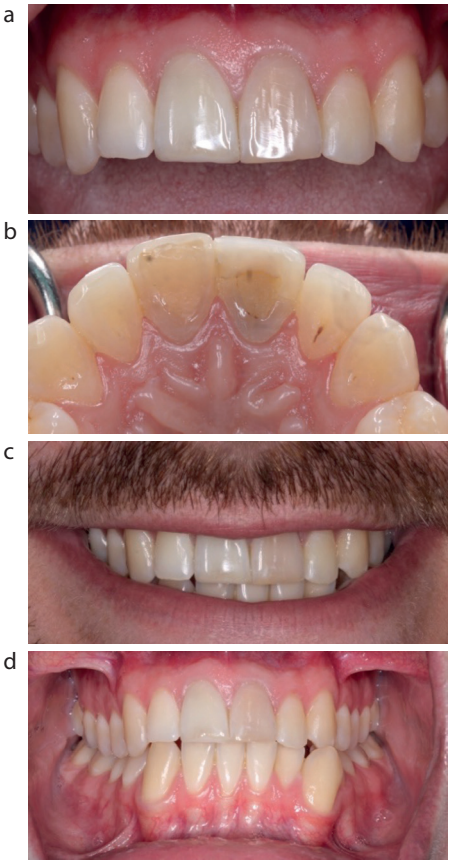


Figure 10. (a–d) Intra- and extra-oral photographs taken at the 8-year post-trauma review.

bleaching of the UR1, the aesthetics were accepted.

Radiographic examination continued to suggest a guarded to poor prognosis despite the excellent clinical picture. Some clinicians may favour extraction of the UR1 and UL1, especially given the UR1 root external resorption and associated radiographic findings. However, the perfect aesthetics would be difficult to restore prosthetically, especially in the anterior zone. The implications of tooth loss for prosthetic tooth replacement are highlighted in Part 1 of this case series. The patient continues to attend for review appointments and reassessment of the dentition.

Discussion

Severe trauma and luxation injuries can have devastating physical and psychological consequences, affecting the patient's quality of life, self-esteem, confidence and function.[10] In this case, loss of the traumatized teeth would have resulted in extensive horizontal and vertical bone loss, with significant soft tissue remodelling, creating challenges for achieving a good aesthetic prosthetic rehabilitation.

This case report demonstrates how severely traumatized teeth can be retained for many years if the acute management and follow-up are good. Timely dental interventions, based on evidence-based guidance, allowed retention of the teeth. Regular dental reviews, which included comprehensive radiographic and clinical assessments, allowed early diagnosis of pathology and management where necessary.

Timely diagnosis of pulpal pathology and the initiation of endodontic treatment for the UR1 and UL1 were carried out, enabling the teeth to be retained in the long term. Replacement options for the 17-year-old would have been limited to a removable partial denture if both teeth were lost or possibly a resin-retained bridge if one tooth was lost. However, the success of resin-retained bridge restoration is highly dependent on the abutment tooth selection, with minimally or unrestored teeth with sufficient enamel for bonding having to be available.[11]

Dental implants are not normally provided for patients until dentofacial growth has ceased.[12] If dental implants are placed too early, they may become progressively infra positioned relative to the adjacent teeth owing to neighbouring teeth moving with continued jaw and facial growth while the implant stays where it was placed; the severity of this can sometimes require implant removal because of very poor aesthetics.[13]

Even when the patient stopped growing, extraction of the upper anterior teeth and prosthetic replacement would not guarantee an aesthetic outcome similar to what the he had, certainly in terms of the pink aesthetics. This would have been more challenging were both upper incisors lost. In cases of two missing adjacent teeth, it is very difficult to recreate a full-length interdental papilla and often a black triangle or teeth with long contact points have to be accepted.

Finally, delaying implant treatment in young patients is essential. This patient would be expected to have an average life expectancy of 80 years.[14] An implant placed in the second decade of life would have to last 50–60 years and, at this stage, there is little evidence on how long implants or their restorations will last. It is thought that the first osseo-integrated dental implant was placed in 1965. While early reports demonstrated implant survival over a 10-year period, there is limited information on long-term biological, functional and aesthetic success beyond this timeframe.[15]

More recent evidence suggests that dental implants have high survival rates of >95% at 5 years and approximately 90% at 10 years, but long-term data beyond 20 years remain limited, particularly in younger patients. Furthermore, complications related to dental implants have been reported to be around 33.6%, including veneer fractures (13.5%), peri-implantitis and soft tissue problems (38.2–44.4%).[16–18]

Delaying tooth extraction and the need for implant treatment means the patient may get through most of his life with one intervention – at least that is what we should be aiming for. Delaying implant treatment, again, reduces the burden on the implants. By retaining the patient's natural teeth, potentially extensive and invasive treatment was avoided in the short to medium term and has potentially reduced the complexity of subsequent fixed prosthodontics.

Root fractures can be challenging to manage, particularly where the fracture is more cervical. However, studies have shown a 10-year survival rate of 89%, 78%, 67% and 33% for teeth with apical, mid-root, cervical-mid-root and cervical fractures respectively.[19] These data suggest that, with appropriate management of root fractures, favourable outcomes can be achieved with long-term tooth retention, minimizing the restorative burden.

Conclusion

Given the aesthetic challenges and the need to reduce the time and clinical burden associated with implant rehabilitation, including the potential need for repeat or complex procedures, it is favourable to retain the natural dentition for as long as possible through good acute management of traumatic injuries, followed by close monitoring and timely intervention to address any complications..

This is demonstrated well in the case presented in this series. When the teeth do eventually need replacing, early interventions can leave a more favourable situation for placing and restoring implants.

Compliance with Ethical Standards
Conflict of Interest: The authors declare that they have no conflict of interest.
Informed Consent: Informed consent was obtained from all individual participants included in the article.

References

1. Glendor U, Andersson L, Andreasen JO. Economic aspects of traumatic dental injuries. In: Andreasen JO, Andreasen FM, Andersson L (eds). *Textbook and Color Atlas of Traumatic Injuries to the Teeth*. 5th edn. Chichester: Wiley-Blackwell, 2018.
2. Andreasen FM, Andreasen JO, Tsilingaridis G. Root fractures. In: Andreasen JO, Andreasen FM, Andersson L (eds). Textbook and Color Atlas of Traumatic Injuries to the Teeth. 5th edn. Oxford: Wiley Blackwell 2018: 377–412.
3. Abbott PV. Diagnosis and management of transverse root fractures. *Dent Traumatol* 2019; **35**: 333–347. https://doi.org/10.1111/edt.12482
4. Hecova H, Tzigkounakis V, Merglova V, Netolicky J. A retrospective study of 889 injured permanent teeth. *Dent Traumatol* 2010; **26**: 466-475. https://doi.org/10.1111/j.1600-9657.2010.00924.x
5. Kallel I, Lagha M, Moussaoui E, Douki N. Lateral luxation: is root resorption an unavoidable complication? *Clin Case Rep* 2022; **10**: e05880. https://doi.org/10.1002/ccr3.5880
6. Clark D, Levin L. Prognosis and complications of mature teeth after lateral luxation: a systematic review. *J Am Dent Assoc* 2019; **150**: 649–655. https://doi.org/10.1016/j.adaj.2019.03.001
7. Flores MT, Andersson L, Andreasen JO et al; International Association of Dental Traumatology. Guidelines for the management of traumatic dental injuries. I. Fractures and luxations of permanent teeth. *Dent Traumatol* 2007; **23**: 66–71. https://doi.org/10.1111/j.1600-9657.2007.00592.x
8. Hermann NV, Lauridsen E, Ahrensburg SS *et al*. Periodontal healing complications following concussion and subluxation injuries in the permanent dentition: a longitudinal cohort study. *Dent Traumatol* 2012; **28**: 386–393. https://doi.org/10.1111/j.1600-9657.2012.01165.x
9. Bourguignon C, Cohenca N, Lauridsen E *et al*. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations. *Dent Traumatol* 2020; **36**: 314–330. https://doi.org/10.1111/edt.12578
10. Koch G, Bergendal T, Kvint S, Johansson UB. Consensus Conference on Oral Implants in Young Patients. *Stockholm: Forlagshuset Gothia* 1996.
11. Gulati JS, Tabiat-Pour S, Watkins S, Banerjee A. Resin-bonded bridges – the problem or the solution? Part 1 – assessment and design. *Dent Update* 2016; **43**: 506–521. https://doi.org/10.12968/denu.2016.43.6.506
12. Mankani N, Chowdhary R, Patil BA *et al*. Dental implants in growing children: a literature review. *J Oral Implantol* 2014; **40**: 627–631. https://doi.org/10.1563/AAID-JOI-D-11-00186
13. McGrath C, Bedi R. Measuring the impact of oral health on life quality in two national surveys – functionalist versus hermeneutic approaches. *Community Dent Oral Epidemiol* 2002; **30**: 254–259. https://doi.org/10.1034/j.1600-0528.2002.300403.x
14. Office for National Statistics. National life tables – life expectancy in the UK: 2020 to 2022. 2024. Available at: www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/bulletins/nationallifetablesunitedkingdom/2022to2024 (accessed February 2026)
15. Brånemark PI, Hansson BO, Adell R *et al*. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg Suppl* 1977; **16**: 1–132
16. Atieh MA, Almutairi Z, Amir-Rad F *et al*. A retrospective analysis of biological complications of dental implants. *Int J Dent* 2022; **2022**: 1545748. https://doi.org/10.1155/2022/1545748
17. Pjetursson BE, Thoma D, Jung R et al. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. Clin Oral Implants Res 2012; **23 Suppl 6**: 22–38. https://doi.org/10.1111/j.1600-0501.2012.02546.x
18. Jung RE, Zembic A, Pjetursson BE et al. Systematic review of the survival rate and the incidence of biological, technical, and aesthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. *Clin Oral Implants Res* 2012; **23 Suppl 6**: 2–21. https://doi.org/10.1111/j.1600-0501.2012.02547.x
19. Andreasen JO, Ahrensburg SS, Tsilingaridis G. Root fractures: the influence of type of healing and location of fracture on tooth survival rates – an analysis of 492 cases. *Dental Traumatol* 2012; **28**: 404–409. https://doi.org/10.1111/j.1600-9657.2012.01132.x