

Contemporary issues in the management of dental trauma

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Key points

Raises awareness of the chronic challenges that dental trauma presents to the profession.

Details specific areas where early treatment can mitigate complications.

Highlights the need for multidisciplinary care in severe and complicated presentations.

Abstract

Contemporary diagnosis and management of traumatic dental injuries requires a multifaceted understanding of the pathological and psychological impact over a patient's lifetime. The legacy of dental trauma injuries can have repercussions for the dentition and supporting tissues, requiring complicated multidisciplinary clinical input. Foresight is required to ensure optimal aesthetic and functional outcomes. Mitigating risks and maximising benefits in patients presenting with polytrauma can be challenging, but if optimally managed at the acute presentation, the long-term burden to the patient and the clinician is reduced. This paper aims to discuss the contemporary clinical dilemmas, challenges and controversies related to the management of dental trauma.

Introduction

At a conservative estimate, utilising meta-analysis, one billion patients worldwide have suffered a traumatic dental injury (TDI).¹ This comprehensive study concluded that TDI is a neglected condition, and could rank fifth among the world's most frequent acute/chronic diseases.¹ As the majority of epidemiological research has been conducted on child and adolescent patients, without due consideration for adult trauma, the actual incidence is likely to be significantly higher. Successful management of acute dental trauma largely depends on the severity of the initial injury, age of the patient and the elapsed time to treatment.² The physical impact commonly results in more than one destructive process that compromises the health of the dental hard and soft tissues of one or more units.



Fig. 1 Sagittal radiographic slice of a 11 with a historical cervical third root fracture that has healed by hard tissue formation



Fig. 2 Clinical photo of a patient with a history of dental trauma that has resulted in the loss of the 21 and infra-occlusion of the 11 and 22. Note the vertical discrepancy in the maxillary hard and soft tissues

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The unattainable ideal would be the complete regeneration of the injured structures. Unfortunately, this has yet to be consistently realised, due to the delay in treatment, a lack of public awareness on prevention, or unmet standards in management.^{3,4,5} The process of healing begins as soon as the injury occurs. Optimal healing is more likely to materialise with prompt management of either fracture or displacement injuries.⁶ For example, root fractures that are poorly approximated are unlikely to heal favourably (Fig. 1). Furthermore, the long-term complications of repair rather than regeneration with poorly repositioned luxated teeth can provide extreme restorative challenges (Fig. 2). In comparison, pulpal responses to injuries can vary. Pulp vitality can be maintained post-injury, can be lost, potentially resulting in cessation of root development, or can be maintained, with the odontoblasts reacting in an attempt to preserve health (Fig. 3). Unfortunately, identifying the correct pulpal diagnosis can be fraught with challenges, which is why a strict longitudinal follow-up creates a more reliable clinical narrative.⁷ Contemporary dental trauma care faces similar issues that need to be addressed by clinicians and researchers for the benefit of the patients. Hence, this review aims to discuss the contemporary clinical dilemmas, challenges and controversies related to the management of dental trauma.

Delivery of acute dental trauma management

Due to the unplanned and unfortunate nature of dental trauma, accessing the right treatment at the right time can be challenging for the patient.⁸ This may be even more difficult when other simultaneous injuries, potentially life-threatening, take precedence. Patients and emergency services can be forgiven for overlooking oral health in favour of preserving the airway or consciousness (Fig. 4).⁹

The most time-sensitive injury is avulsion. As a result, it is recommended that replantation should best be conducted by the patient or someone at the scene of the injury. The presence of mind from patients or the public is important, as teeth replanted within 15 minutes have a significantly greater prognosis, which reduces exponentially until 60 minutes and subsequently becomes very poor and unpredictable.¹⁰ Therefore, public health initiatives to increase awareness on

avulsion management are likely to improve outcomes.¹¹ Engagement with professionals, such as school teachers and emergency care workers, is also likely to reduce the burden on primary and secondary care dental services and the subsequent morbidity and legacy of the injury.¹²

Once the patient presents to a dentist, the diagnosis of all issues and injuries is vital. In order to maximise time efficiency, a standard protocol for a concise history of neurological trauma (loss of consciousness, amnesia, vomiting) and a description of the traumatic episodes (answering the questions of 'when', 'where' and 'how'), followed by medical history and habits is key. Often, asking for a pre-injury photograph of face and smile are also required,

which is especially pertinent with displacement injuries.¹³

Dental injuries rarely occur in isolation. Often, multiple teeth can be affected, or a single tooth may have several injuries. Severe injuries can distract the attention of the operator, resulting in injuries that go undiagnosed to only be realised at a later date once signs and symptoms develop (Fig. 5).¹⁴ Hence, identification of the source of bleeding, haemostasis, removal of dirt and other foreign bodies must precede the clinical examination to improve the visibility and accessibility of the field.

Multiple radiographs from various angulations and soft tissue radiographs are required to ascertain the full extent of fracture

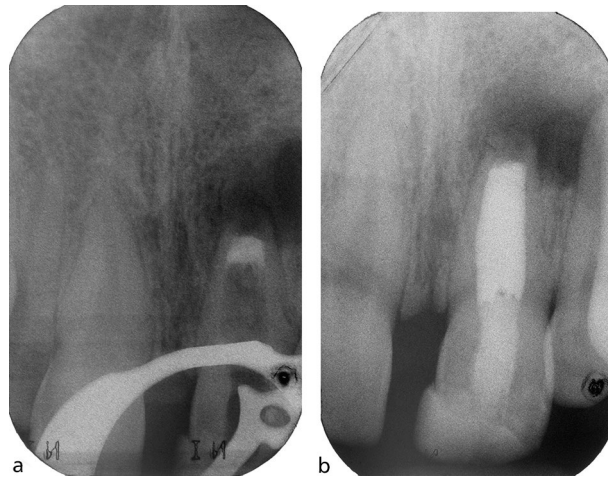


Fig. 3 a, b) Immature non-vital 21 with the classic 'blunderbuss' shaped apex. The tooth was treated with an apical plug of MTA and the remaining canal system obturated with gutta-percha

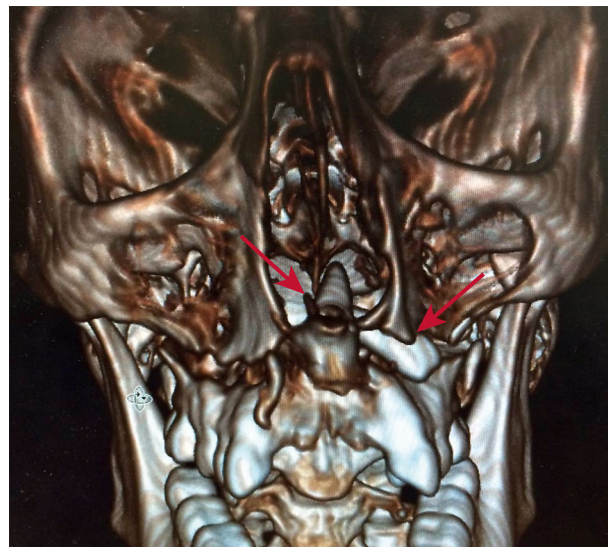


Fig. 4 This patient suffered a road traffic accident resulting in both central incisors (red arrows) becoming lodged between his maxilla and floor of nose. At the time of the accident, paramedics were unaware of the tooth position until the patient was examined with CBCT

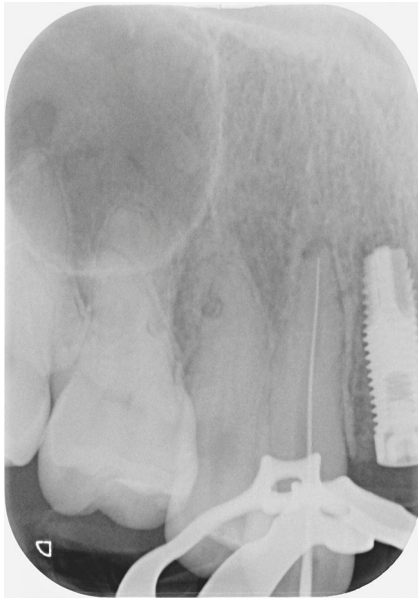


Fig. 5 Working length radiograph of the 13 that revealed itself to be non-vital two years post-trauma and soon after implant provision. Note the healed fixation screw defect on the distal portion of the 14 root

lines or broken/displaced tooth or fragments. Cone beam computed tomography (CBCT) can be utilised in cases that are complex involving multiple units (Fig. 6).¹⁵ This needs to be balanced against the relative exposure to the patient and the risks of delayed management for those conditions.

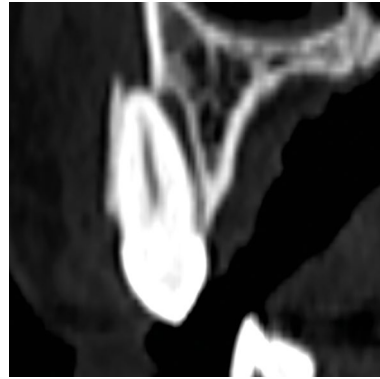


Fig. 6 CBCT identifying lateral luxation of the 13 subsequent to assault. This injury was not identified at the initial clinical examination stage

Onward referral to secondary care services may be required to satisfy the gold standard of care that has been internationally recognised.¹⁶ Clinicians should be aware of local dental trauma services to reduce unwanted delay in referral. At this stage, the complexity and magnitude of the pathologies may warrant multidisciplinary care, despite appearing costly within insurance or public services.¹⁷ This approach takes particular precedence in children and adolescents due to the stage of developing dentition and the likely lifelong legacy of the injury (Fig. 7).¹⁸

Psychological component of dental trauma

The prevalence of mental health issues as a result of general trauma is well-documented.¹⁹ As might be expected, the mental health component of dental trauma has been investigated to a lesser degree.²⁰ The inter-relationship of mental health and physical health is of paramount importance. Where patients suffer from post-traumatic stress, the constant reminder of the incident through attendance for dental treatment is an undeniable factor to consider in the planning of treatment. This is even more prevalent in children who may develop psychological problems due to a missing anterior unit or an aesthetic issue. In the International Association of Dental Traumatology (IADT) 2020 guidelines, this aspect has been well-documented, with additional emphasis on minimising stress to an already traumatised child.²¹ As such, multidisciplinary management should extend to the involvement of psychology colleagues to aid mental health healing in tandem with physical healing. Historically, this may not have seemed to be of any crucial importance, but it is considered imperative in contemporary traumatology, as the ability of patients to attend, comply and appreciate the treatment outcomes directly correlates to their mental wellbeing.²² The tangible benefits of psychological management may only become apparent towards the end of treatment, however successful or compromised the outcome may be.



Fig. 7 This patient suffered avulsion of 12, 11, 21 and 22 in her adolescence. Note the significant scar tissue and vertical and horizontal bone defects. The clinical photograph unfortunately cannot provide a measure of the post-traumatic stress she underwent due to the injury

Another aspect that the clinician needs to consider is the stages of grief (Fig. 8). The acute presentation of the patient to the dental setting, where the injury suffered is recent, may coincide with feelings of shock, denial or anger. These phases of emotion can prevent delivery of treatment. For example, patients in



Stages of Grief

Fig. 8 The stages of grief which all clinicians should be mindful of when managing dental trauma patients

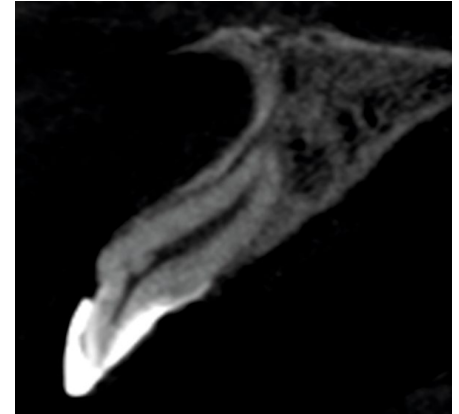
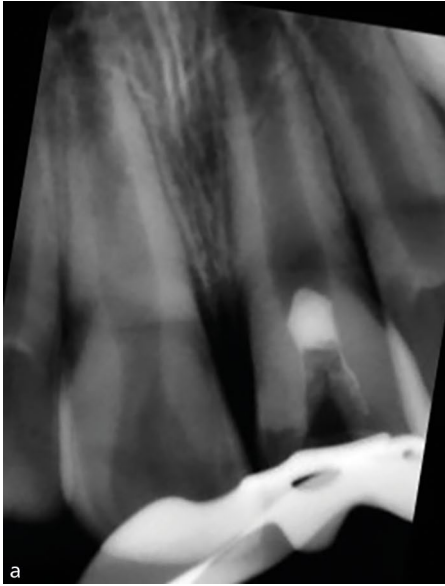


Fig. 10 A dilacerated 11 as a consequence of trauma to the deciduous dentition

tooth germ puts the permanent successor at risk of long-term sequelae (Fig. 10).

Discolouration

Pulp canal obliteration (PCO) is a process whereby a vital pulp lays down tertiary dentine resulting in a more intense dentine colour, partly due to the increased root wall thickness, and is considered a favourable outcome after dental trauma (Fig. 11, Fig. 12). On average, only 11% of PCO teeth go on to develop pulp necrosis.²⁷ The discolouration is commonly misinterpreted as loss of pulp vitality and inappropriate endodontic treatment may be initiated. The importance of multiple clinical and radiographic findings over a period of time cannot be over-emphasised, which combine to conclude a more definitive pulpal diagnosis.

A more contemporary issue has been the discolouration of traumatised teeth subsequent to endodontic treatment utilising bioceramic materials (Fig. 13).²⁸ Their use is indicated for vital pulp therapy or the management of an open apex. Unfortunately, over time, the

Fig. 9 a, b) Vital pulp therapy performed on an eight-year-old patient with the aim of preserving vitality for continued root development. Note the dentine bridge formation and the continued root development with thickening of the root canal walls and apical foramen closure

denial about the injury may not present soon after the injury as they are struggling to come to terms with the event. Equally, patients managing anger or frustration may struggle with the need for invasive dental treatment or the acceptance of poor prognosis associated with their TDI. Frustratingly, these challenges may be compounded when patients have no experience of dental treatment due to previous optimal oral health. Incorporating input from psychology colleagues within a multidisciplinary environment can improve clinical outcomes.²³ Similar psychological issues need to be explored among the sports persons affected by TDI. A phenomenon of 'kinesiophobia' or fear of re-injury has been identified in athletes with orthopaedic injuries, especially involving the cruciate ligament.²⁴ This makes them anxious and delay their return to practice and competitive sport, ultimately affecting their performance.²⁴ Furthermore, the negative effects of TDI on patients' quality of life has been assessed.²⁵ Hence, due consideration should be given in developing a holistic management protocol with adequate follow-up rather than focusing on purely clinical provision of treatment.

Developing dentition

The highest incidence of dental trauma has been reported in the 9–12 years age group, with higher preponderance in boys.¹ Therefore, it is expected that a significant quantum of dental

trauma management worldwide is either the acute manifestation in an injured adolescent, or the adverse consequences of faulty/failed or even absence of treatment in an older age group or adulthood. As a result, the primary objective should be to preserve pulp vitality and promote apexogenesis of immature roots in the developing dentition (Fig. 9).²⁶

A contemporary issue, rarely addressed by any guidelines, is the presence of primary teeth adjacent to injured permanent teeth requiring splinting. Therefore, flexible splinting in developing dentitions might be done by utilising the firm primary teeth, whose numbers and extent may be determined by the stage of their root resorption or the severity of trauma.

The proximity of the roots of primary anterior teeth to the developing permanent



Fig. 11 The 11 that has been previously traumatised. Note the deeper orange discolouration due to the increased thickness of reactionary dentine being created. This is not an indication of pulp necrosis



Fig. 12 a, b, c, d) Radiographs showing a 12 with pulp canal obliteration and a periapical radiolucency before and after root canal therapy



Fig. 13 A progressively discolouring 11 caused in part by the presence of MTA within the canal system. Note that the discolouration is projecting through the full contour composite restoration



Fig. 14 ECR engulfing the distal portion of the 21 subsequent to a history of trauma

bismuth oxide component of mineral trioxide in particular results in dark discolouration. Contemporary hydraulic cements have reduced the risk of discolouration and should be considered by clinicians.

Root resorption

External cervical resorption (ECR) is associated with traumatised teeth, as well as units that have been treated orthodontically.²⁹ The classic signs of a painless pink spot that develops within the crown, signifying a firm subgingival lesion that bleeds on probing, have now been challenged to include a much greater variation in presentation (Fig. 14, Fig. 15).³⁰ Treatment of ECR involves gaining access to the lesion, chemically and mechanically debriding it in its entirety, and providing a restoration for adequate healing (Fig. 16). Unfortunately, early signs of ECR are subtle, but timely diagnosis is a significant component as lesions can engulf the majority of the tooth, making it unsalvageable (Fig. 17).³¹

Internal inflammatory resorptive lesions provide a different challenge due to changes in the internal root canal anatomy (Fig. 18).³² The resorptive lesion results in an elliptical defect within the root canal anatomy. This necessitates the chemical debridement of the areas that are likely to harbour biofilm and are inherently inaccessible to common mechanical instrumentation.³³ As such, irrigation adjuncts are required to aid disruption of the biofilm. This can be achieved through producing shear stresses in the irrigants by ultrasonic devices.³⁴ Once the debridement and preparation stages are completed, obturation can commence with thermoplastic or packable materials or hydraulic cement if the resorption has perforated the root canal wall.

The inability to differentiate between internal and external resorption can result in inappropriate treatment. Therefore, 3D imaging is routinely recommended where there may be ambiguity on a definitive diagnosis before treatment commences.³⁵

External inflammatory root resorption can manifest between 2–8 weeks post-injury, especially after pulpal necrosis (Fig. 19).³⁶ Late manifestation of all these conditions can result in catastrophic outcomes (Fig. 20). As such, early diagnosis of these issues allows for remedial treatment that can avoid destruction in traumatised teeth.

Replacement resorption (ankylosis) is the process whereby a necrosed periodontal

ligament results in bone formation along the denuded root surface. This process is most common after severe luxation, intrusion, or delayed re-implantation.³⁶ The tooth has a high-pitched tone on percussion, becomes immobile and cannot accommodate occlusal forces or be moved orthodontically.³⁷ In growing patients the injured tooth is stunted in its position resulting in an incisal edge discrepancy or infra-occlusion (Fig. 21). The aesthetic issue of incisal edge asymmetry may distract from the catastrophic lack of vertical alveolar bone and soft tissue development in this site. This, over the period of many years, can result in a demanding situation when the tooth requires prosthetic replacement.

Decoronation, as described by specialist teams in Scandinavia, aims to promote a favourable outcome where bone and soft tissue can continue to develop.³⁷ This involves removal of the crown and remnant enamel until the cemento-enamel junction, and if possible, induction of bleeding from the apical region (Fig. 22).³⁶ The resorptive process slowly assimilates the root portion and ideally results in an alveolar bone level that is comparable to the adjacent, non-traumatised tooth. Endodontic treatment will not affect the progress of replacement resorption; in fact, the endodontic obturation material can complicate future dental implant surgery. Therefore, endodontics should be performed only if the pulp loses vitality with the canal and can be dressed with calcium hydroxide paste indefinitely rather than obturated with gutta-percha.

Historical peri-radicular disease

One particular challenging aspect of the management of patients who have suffered TDI is the unfortunate development of large lesions associated with multiple teeth (Fig. 23). Correct diagnosis of the offending tooth can be challenging but will avoid inappropriate orthograde or even surgical intervention of the unaffected adjacent teeth, which can, in turn, cloud clinical judgement on future interventions. Due to the extension of the lesion in the bucco-palatal direction, the risk of healing through scar tissue development is increased (Fig. 24).³⁸ Clinicians may consider surgical intervention as the best option, when in reality, the evidence shows that traditional *de novo* orthograde root canal treatment can resolve large lesions over time and without haste.³⁹

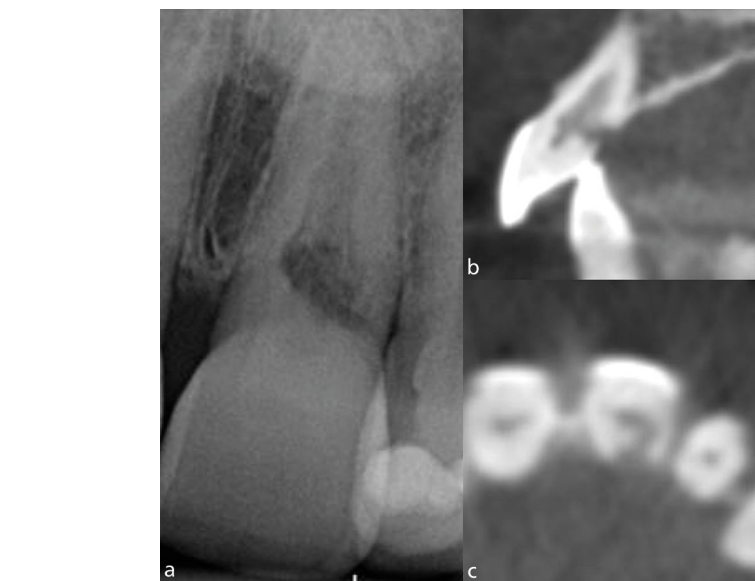


Fig. 15 a, b, c) 2D and 3D images of external cervical resorption affecting the palatal aspect of the 21. Note there is no apical radiolucency that would indicate pulp necrosis

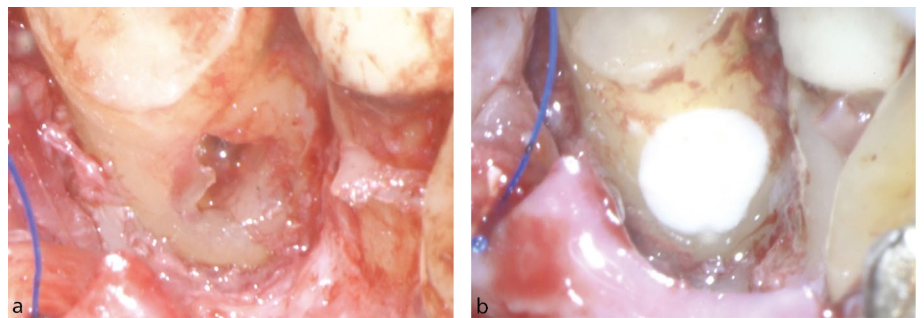


Fig. 16 a) The palatal aspect of a 21 with an external cervical resorption defect (portal of entry) after elevation of a full thickness flap. b) The same external cervical resorption defect after mechanical and chemical debridement and restoration with glass ionomer

Endodontic regeneration

Loss of vitality of permanent teeth with incomplete root formation is less than ideal because of the inherent lack of mechanical strength due to short root length, wide open apical foramen and thinner dentinal walls, not to mention the necrotic remnants and bacterial degradation products.⁴⁰ Historically, their endodontic management involved either repeated placement of calcium hydroxide for apexification or endodontic surgery.⁴¹ However, with the advent of bioceramics and materials such as mineral trioxide aggregate (MTA), the apical barriers can be prepared in one session and the tooth obturated (Fig. 3).⁴² As previously discussed, this can result in discolouration in an already structurally compromised unit.

To overcome these issues, in the early 2000s, the regenerative endodontic paradigm was



Fig. 17 External cervical resorption of the 21 that has progressed resulting in significant restoration challenges



Fig. 18 a, b) Internal inflammatory root resorption present on the 11 and a fractured file in the 21. These units were later successfully root canal treated and restored



Fig. 19 a) Radiograph taken soon after avulsion of the 21 and replantation. b) Development of external inflammatory root resorption mesially and distally in the cervical areas, two months after the initial injury



Fig. 21 Replacement resorption resulting in severe discrepancy in incisal edge and tooth position. The 21 site had severe alveolar and soft tissue underdevelopment as a result



Fig. 20 Replacement resorption on the 21 unit. Note the presence of bone superimposed within the canal outline

papilla.⁴⁴ Theoretically, these undifferentiated cells develop into pulp cells through contact with the dentine surface and growth factors present on the surfaces. This has been shown to result in the regression of apical lesions, as well as apical closure and continued root development. The continued development of the root anatomy has been sporadic in the nature of its reporting and indeed may be considered ‘hit and miss’, despite being biologically lucrative for the patient and the clinician.⁴⁵

Regenerative endodontics meets the biological needs of a traumatised, non-vital, permanent tooth with incomplete root formation, but predictability of the procedure through research evidence is yet to be realised.⁴⁶

Hard and soft tissue defects

The greater the severity of dental trauma, the greater the likelihood of involvement and loss of bone within the alveolus. The key aspect for units in the aesthetic zone is the regression of bundle bone connected to the periodontal ligament after avulsion or extraction.⁴⁷ Once a tooth is avulsed or extracted, the proprioceptive stimulation of the surrounding bone through the tension within the ligament disappears and so begins the process of resorption. This has significant repercussions for future tooth replacement, where the ideal housing of a dental implant

developed.⁴³ The techniques that have been described are based on the repopulation of the inner root canal dentine surface with cells from Hertwig’s epithelial root sheath and apical

within native alveolar bone is unachievable (Fig. 25). Numerous bone augmentation techniques to remedy this issue have been described elsewhere.⁴⁸ The larger the area that needs to osseointegrate and be perfused, the more challenging and the greater the risks involved (Fig. 26).

The unfortunate reality is that bone grafting in a vertical dimension may not solve the issue of depleted bone stock and clinicians are often forced to consider options other than the provision of dental implants.⁴⁹

Further, the chronic presentation of a large apical lesion can more than likely result in a post-extraction defect (Fig. 24). These aspects need to be considered carefully during treatment planning. In some cases, the clinician may elect to provide endodontic treatment for an otherwise 'unrestorable' tooth, purely for the purposes of maintaining or regenerating the apical bone (Fig. 23).

The adjunctive loss of keratinised or 'scarred' tissue may not be of immediate concern. However, when performing endodontic microsurgery, bone grafting, or dental implant placement, the diminished keratinised tissue or scarred periosteum results in a tissue which is difficult to manipulate and potentially less amenable to the long term-stability of the restorative treatment. Therefore, clinicians should carefully consider the implications of their treatment in the present and possibly more importantly, how it may affect the patient's future options, as the restorative cycle is inevitable.

Dental implant complications

Dental implants, despite being the most modern method of tooth replacement, experience biological and mechanical complications (Fig. 27).^{50,51,52}

Dental implant provision is best delayed until maxillary growth is completed where the likelihood of infra-occlusion is less likely to develop (Fig. 28).⁵³ However, even patients well into adulthood can subsequently present with infra-occlusion of their dental implant.

Peri-implantitis is a known and established disease entity within the world of implantology.⁵⁴ The disease process results in the inflammation of the peri-implant soft and hard tissues which results in circumferential bone loss (Fig. 29).

This is especially relevant to the dental trauma cohort where implants may be considered the gold standard for anterior

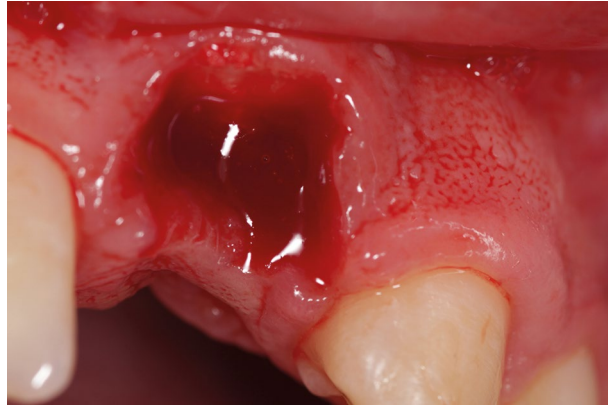


Fig. 22 The 21 was decoronated at the alveolar level. Bleeding was encouraged coronally and within the canal system

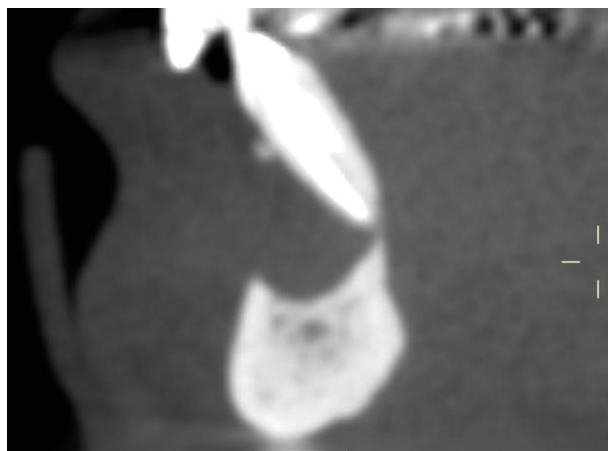


Fig. 23 Sagittal radiographic section of a previously traumatised 31 that has been endodontically treated to reduce the size of the large periapical lesion

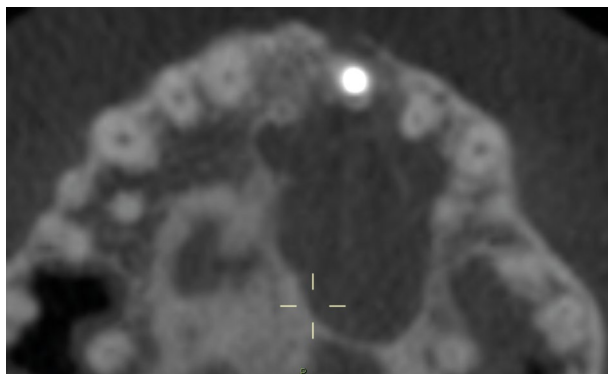


Fig. 24 A large amorphous lesion associated with the 22 in a patient with a history of trauma to multiple units

tooth replacement (Fig. 30).⁵⁵ Since trauma prevalence is high in younger patients and so the need for tooth replacement, the likelihood and cumulative risk of complications increases when compared to older cohorts, as the prostheses will be in service for potentially many years or decades.⁵⁶

A reliable method to manage peri-implantitis has yet to be realised, although risk factors have been identified to aid prevention.⁵⁷ The presence of periodontal disease, poor oral hygiene and those with systemic disease all present with a greater risk of development.⁵⁸ As such, clinicians should



Fig. 25 Horizontal and vertical hard and soft tissue defect of the anterior maxilla after dental trauma. Note the significant attachment loss of the adjacent teeth and general poor dental maintenance, all of which are limiting factors for guided bone regeneration

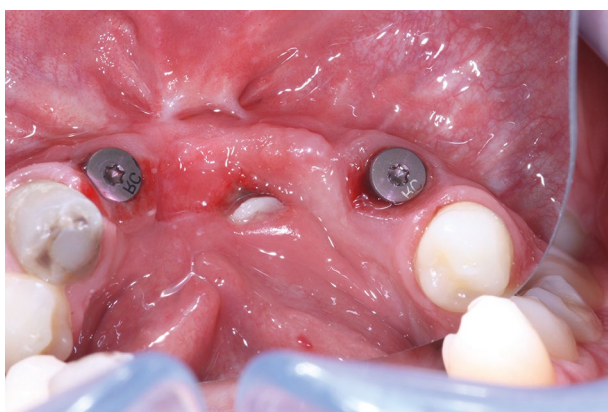


Fig. 26 Failed onlay graft for a patient with a history of midline fracture of the mandible. The graft exposure occurred post-implant placement

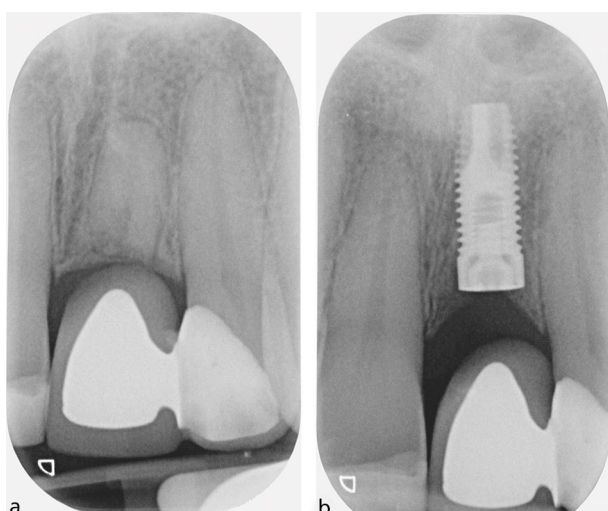


Fig. 27 a, b) A retained root in the 21 region that was maintained with the aim of bone preservation until such time the patient was ready for implant provision. Note the resin-bonded bridge was utilised pre-implant placement and post-implant placement to avoid denture wear

look to instigate strategies that minimise the development of the disease through recommending smoking cessation, the attainment of systemic health and improving oral hygiene.

The positive and negative effects of social media and dental trauma

The digital age has resulted in a multitude of instant limitless avenues through which we can communicate with one another. This expansive tool allows us to disseminate information quickly and rapidly while also connecting with people anywhere in the world. Due to the relative penetrance of the internet and social media in society, it has also had an undoubted effect on the aetiology and subsequent management of dental trauma.

The unfortunate advent of trolling or online bullying has been shown to manifest itself or result in physical harm, including dental trauma.⁵⁹ The injuries that may present are severe, but as discussed earlier, the mental component is of paramount consideration. Delivering the news of prognoses of teeth where the outlook is not clear or very poor is likely to need psychologist support. Patients with severe depression or anxiety may not be able to comprehend the need for extensive dental treatment or the loss of teeth at a time.

Digital media can have a positive effect on the management of trauma. Information on how to manage acute conditions, such as avulsions, is widely available on search engines and the IADT ToothSOS app.⁶⁰ Therefore, the injured person, or any member of the public, can reposition a tooth in a timely and efficient manner and so improving prognosis.⁶¹ Such instant relevant information will undoubtedly improve outcomes without any real need for investment in training or resources. Unfortunately, a related phenomenon reported recently was the possibility of TDI due to trips and falls when operating smartphones and related devices.⁶²

Conclusion

Contemporary issues in dental traumatology make it a complicated proposition for healthcare professionals and increase the burden on the affected patients and their families.

Dental professionals should keep themselves updated with recent guidelines and contemporary management modalities so that they are confident to perform remote management, emergency care and follow-up for the benefit of the patient in

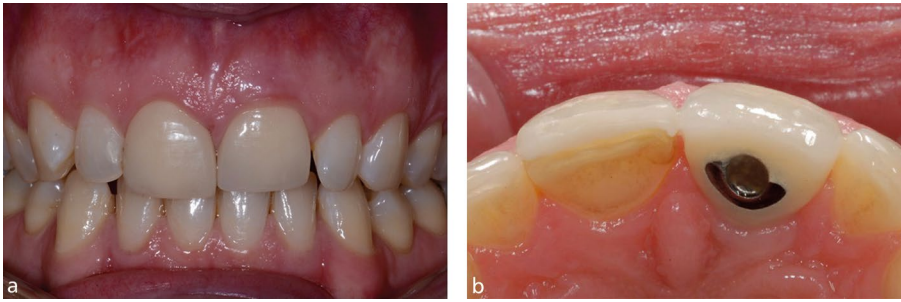


Fig. 28 a, b) Clinical presentation of an implant in the 21 position that was lost due to dental trauma and after 13 years has infra-occluded – note the apical position of the incisal edge and gingival swelling

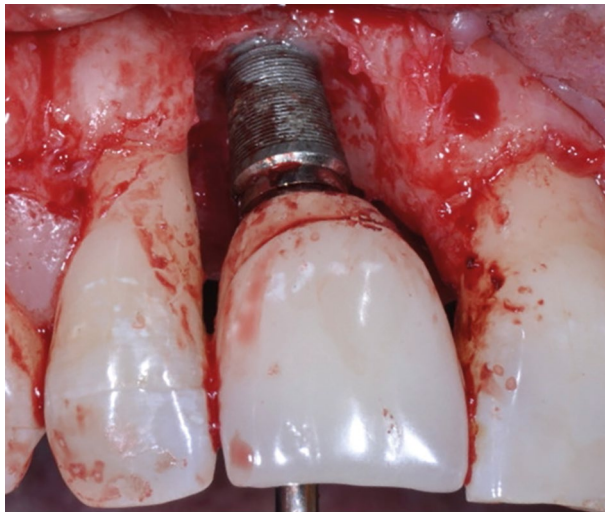


Fig. 29 Circumferential crater defect caused by peri implantitis of the implant in the 11 position. Note the adjacent bone loss of the mesial aspect of the lateral incisor due to the proximity of the implant in comparison to the adjacent central incisor. This loss of attachment on the mesial of the lateral incisor is catastrophic for papilla aesthetic and potential guided bone regeneration



Fig. 30 Clinical photo of the local risk factors associated with peri-implantitis including, plaque, plaque retentive margins, excess cement and suboptimal prosthetic emergence

the short-term, but just as importantly, the long-term legacy. As this cohort will embark on the restorative cycle at a relatively young age, every effort should be made to balance our clinical footprint in the present with potentially limiting any future restorative options.

Ethics declaration

The authors declare no conflicts of interest.

Author contributions

Aws Alani, Nitesh Tewari and Gareth Calvert all conceived and produced this article.

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