The treatment of traumatic dental injuries

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By Dr Asgeir Sigurdsson, USA

When treating dental trauma, the timeliness of care is key to saving the tooth in many cases. It is, therefore, important for all dentists to have an understanding of how to diagnose and treat the most common dental injuries. This is especially critical in the emergency phase of treatment. Proper management of dental trauma is most often a team effort with general dentists, pediatric dentists or oral surgeons on the front line of the emergency service, and endodontic specialists joining the effort to preserve the tooth with respect to the pulp, pulpal space and root. An informed and coordinated effort from all team members ensures that the patient receives the most efficient and effective care.

Recently, a panel of expert members of the American Association of Endodontists prepared an updated version of Guidelines for the Treatment of Traumatic Dental Injuries.[1,2] These guidelines were based, in part, on the current recommendations of the International Association of Dental Traumatology (see www.iadtdental-trauma.org for more information). This article provides an overview of the AAE guidelines; the complete guidelines are available for free download at www.aae.org/clinical-resources/trauma-resources.aspx. The benefit of adhering to guidelines for treatment of dental trauma was recently shown in a study by Bucher et al.[3] The study found that, compared with cases treated without compliance to guidelines, cases that adhered to guidelines produced more favorable outcomes, including significantly lower complication rates. The study also found that early follow-up visits were essential to ensure prompt treatment of complications when they arose.[3]

Fig. 1a: Clinical case of two uncomplicated crown fractures in which the two broken pieces were located and reattached. (Photos/Provided by American Association of Endodontists)

Figs. 1b, c: After the two pieces had been attached, a chamfer was cut along the fracture line and additional composite cured in place. This will both increase the strength of the attachment and better hide the fracture line.

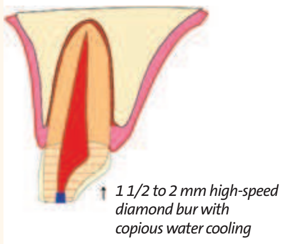

Fig. 2a: Schematic diagram of minimal pulpotomy, where an approximately 2-mm reservoir is cut with a high-speed diamond bur and copious water cooling and calcium hydroxide mixed with sterile water placed. (Schematic drawings/Provided by Dr. Sigurdsson)

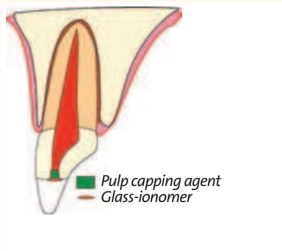

Fig. 2b: Glass ionomer or a protective liner is placed over the pulp capping agent to ensure it stays in place during etching and bonding.

Fig. 2c: Clinical pictures of the minimal pulpotomy.

Emergency care

Prior to any treatment, one must evaluate the injury thoroughly by careful clinical and radiographic investigation.

It is recommended to follow a check list to ensure that all necessary information regarding the patient and the injury is gathered, including:
1. Patient's name, age, sex, address and contact numbers (include weight for young patients).
2. Central nervous system symptoms exhibited after the injury.
3. Patient's general health.
4. When, where and how the injury occurred.
5. Treatment the patient received elsewhere.
6. History of previous dental injuries.
7. Disturbances in the bite.
8. Tooth reactions to thermal changes or sensitivity to sweet/sour.
9. If the teeth are sore to touch or during eating.
10. If the patient is experiencing spontaneous pain in the teeth.

Once all of this information is gathered, a diagnosis can be made and appropriate treatment rendered. If the injured individual is not a patient of record, all necessary demographic information should be gathered as soon as the patient arrives and prior to any assessment.

In the case of avulsion and the tooth being out of its socket, one should immediately place the tooth in a physiological solution of specialized media (such as Hank's Balanced Salt Solution) or milk, or saline if those are not available. Only after the tooth is secured in solution should one obtain the patient's information. Once the patient is seated in the dental chair, it is necessary to do a quick central nervous system (CNS) evaluation before proceeding with further assessments.

Often, the dentist is the first health-care provider to see the patient after a head injury (any dental trauma is, by definition, a head injury) and must assess the risk of concussion or hemorrhage. It has been estimated by a meta-analysis that the prevalence of intracranial hemorrhage after a mild head injury is 8 percent, and the onset of symptoms can be delayed for minutes to hours.[4] The most common signs of serious cerebral concussion or hemorrhage are loss of consciousness or post-traumatic amnesia. Nausea/vomiting, fluids from the ear/nose, situational confusion, blurred vision or uneven pupils, and difficulty of speech and/or slurred speech may also indicate serious injury.[5]

Once the patient has been cleared of any CNS issues, the dental trauma should be assessed. The key is to obtain comprehensive information about the injury and, to do so, one must conduct thorough extra-oral and intraoral clinical exams as well as appropriate radiographic evaluations.

The new AAE guidelines recommend taking one occlusal and two periapical radiographs with different lateral angulations for all dental injuries, including crown fractures. If cone-beam computed tomography is available, it should be considered for more serious injuries, such as crown/root, root and alveolar fractures, as well as all luxation injuries.

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Table 1. Follow-Up Procedures for Fractured Permanent Teeth and Alveolar Fractures

TIME	Crown Fracture		Crown-Root Fracture		Root Fracture	Alveolar Fracture
	Uncomplicated	Complicated	Uncomplicated	Complicated		
4 Weeks					Splint removal*, clinical and radiographic control	Splint removal and clinical and radiographic controls
6-8 Weeks	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control
4 Months					Splint removal**, clinical and radiographic control	Clinical and radiographic control
6 Months					Clinical and radiographic control	Clinical and radiographic control
1 Year	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control	Clinical and radiographic control
Yearly for 5 Years					Clinical and radiographic control	Clinical and radiographic control

*Splint removal in apical third and mid-root fractures; **Splint removal with a root fracture near the cervical area

(Tables/Provided by American Association of Endodontists)

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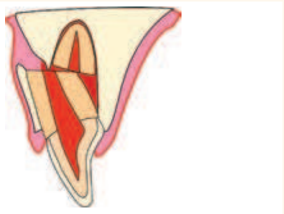
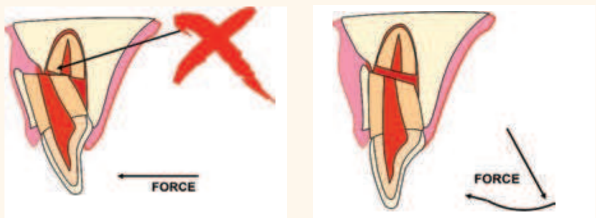


Fig. 3a: Schematic drawing of a common situation after root fracture: The crown portion is displaced inward toward the palate and the fractured piece is stuck to the facial cortical plate.



Figs. 3b, c: It is impossible to move the coronal portion back to its original location without releasing it from the cortical plate. This is accomplished by pulling the coronal portion down and then repositioning it.

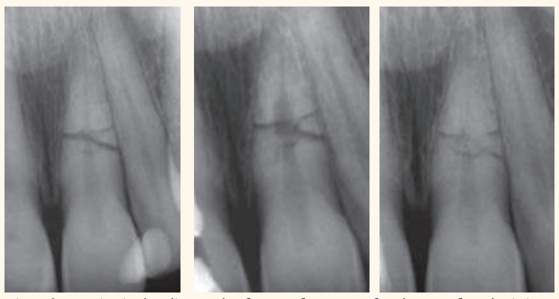


Fig. 3d: A periapical radiograph of a root fracture a few hours after the injury. It was established that both fragments were in good approximation of each other. Splinting was done for two weeks.
Fig. 3e: At the nine-month recall, internal root resorption was noted, but no defect in the PDL or adjacent bone, indicating a 'normal' healing process.
Fig. 3f: Five-year recall, no endodontic treatment was needed.

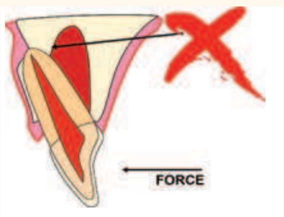
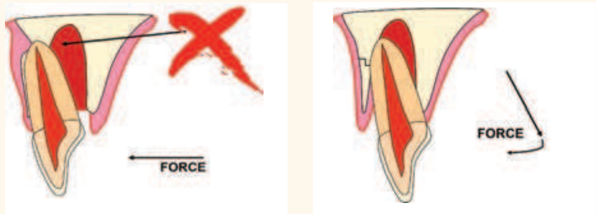


Fig. 4a: In lateral luxation injuries of maxillary teeth, the apex is frequently pushed through the cortical plate facially.



Figs. 4b, c: To reposition the tooth, it has to be released prior to moving the crown forward.

Fig. 5: Once the tooth has been repositioned, the patient bites into a softened pink wax plate that had been previously rolled one or two times. This will ensure that the luxated (or avulsed) tooth stays in place while being splinted. In this case, a 16-pound fishing line was used as the splint on the luxated tooth.

Additionally, sensibility tests should be conducted on all teeth involved as well as opposing teeth. Cold testing is recommended over electric pulp testing in young individuals.[6] Both testing methods should be considered, however, especially when there is no response to one of the two. The pulp might be non-responsive for several weeks after a traumatic injury, so a pulp test should be done at every follow-up appointment until a normal response is obtained.[7]

Once the diagnosis is confirmed and more serious complications such as CNS and jaw or other facial bone fractures have been ruled out, the emergency phase of the treatment needs to be initiated. The aim of treating dental trauma should be to either maintain or regain pulpal vitality in traumatized teeth. This is because dental trauma most frequently occurs in preteens or young teens in whom the teeth have not yet fully developed, and root development will cease without a vital pulp.

Clinical examples

Dental trauma can be roughly divided into two groups: fractures and luxation injuries. The fractures are then further divided by type: crown, crown-root and root fractures. If the pulp is exposed to the oral environment, it is called a complicated fracture; if not exposed, it is called an uncomplicated fracture.

Crown fractures:

The first thing to do in any crown or crown-root fracture is to look for the broken-off tooth fragment.
With modern bonding technology it is possible to rebond the fragment to the tooth, which is esthetically the best solution. Prior to reattaching the tooth fragment, the remaining dental thickness immediately covering the pulp needs to be assessed radiographically and clinically. If there is at least 0.5 mm of the dentin remaining, there is no need to cover it with a protective liner. If it is estimated that the remaining dentin is less than 0.5 mm, it is advisable to cover the deepest part, closest to the pulp, with a cavity liner, and then dimple the fragment accordingly.[8,9] If the tooth fragment was kept dry, it should be rehydrated in distilled water or saline for 30 minutes prior to reattachment. This process will increase its bonding strength10 (Figs. 1a–c).

In a complicated fracture, the goal is to create a bacteria-tight seal to protect the pulp, after ensuring that the pulpal wound is clean and all inflamed tissue removed.[11,12] The two best capping materials available today are calcium hydroxide and mineral trioxide aggregate (MTA),[13,14] but newer bioceramic materials are showing promise for this application. It is advisable to create a 1-2 mm reservoir into the pulp with a high-speed diamond bur and copious water cooling, place the capping material, and then either reattach the tooth fragment or restore the crown with a composite resin material (Figs. 2a–c).

Crown-root fractures

One of the more challenging types of fracture to treat is the crown-root fracture because the fracture margin has to be exposed around the tooth/crown to properly restore the tooth. This can be accomplished by gingivectomy if the fracture line is in the sulcus. In more extreme cases, the tooth will have to be extruded with orthodontic forces or surgically repositioned. In the emergency session, if the pulp is exposed, it needs to be protected in the same fashion as complicated crown fractures.

If the pulp is not exposed, all accessible exposed dentin areas should be covered for the patient's comfort.

Pulpal survival for all these fracture types is generally good; however, endodontic treatment may be indicated later.[15,16] Therefore, it is of utmost importance that a recall schedule is followed and that the teeth involved in the trauma are tested every time. Tables 1 & 2 outline the recommended recall rates for most common dental injuries. It is not uncommon for there to be no response to vitality tests for up to three months, and a lack of response to vitality tests does not always indicate that root canal treatment is needed—especially in young and immature teeth. Rather, it is advisable to look for at least one other sign of pulpal necrosis, such as vestibule swelling, periapical lesions and/or dramatic color change of the crown. If no signs exist, continue to monitor the patient at regular appointments every three months, for up to one year.

Root fractures

The pulp is affected in all root fractures. However, if the fragments are approximated soon after the fracture, there is a good chance that no endodontic treatment is necessary, just observation. With good approximation, it is likely that the pulp will revascularize across the fracture regardless of the age of the patient[17], 18 (Figs. 3a–f). A recent retrospective study included assessment of splinting type and time of root fracture. The study determined that, if the cervical portion of the tooth is stable once the two pieces have been approximated, no splint or a flexible splint for two weeks produces the best treatment outcome.[2,18] Longer splinting time is recommended only when the fracture is close to the cervical area.

Luxation injuries

All luxation injuries will cause some damage to the periodontal ligament and, in some cases, the pulp as well. The immediate treatment is to limit further damage to the PDL and allow for the best possible healing.
As with all dental injuries, follow-up is essential. Late complications, such as internal or external root resorptions, are relatively frequent and require endodontic treatment, especially in more severe injuries. In many of these cases, referral to an endodontist is advisable.
Luxation injuries are divided into subcategories, mainly by degree of severity. The two mildest are termed "concussion" and "subluxation." In those cases, the tooth is still in its original location, but is tender to percussion and/or, in the case of sub-luxation, has increased mobility. While no immediate treatment is needed for these injuries, follow-up is critical because the pulp may become necrotic, making endodontic intervention paramount.
When trauma has moved the tooth out of its normal position, it needs to be replaced gently as soon as possible.
The only exceptions are cases of intrusion when it might not be possible or advisable to manipulate the tooth immediately. When an immature tooth is intruded up to 7 mm, it is recommended to wait three weeks and watch for signs of re-eruption. If no signs exist, one can initiate orthodontic repositioning. For intrusion of more than 7 mm, surgical or orthodontic repositioning should be performed with in three weeks.

In the case of an intruded tooth with a closed apex, there is a possibility of re-eruption if the tooth is slightly intruded (less than 3 mm) and the patient is younger than 17 years old. If the tooth is not moving after two to three weeks, however, orthodontic extrusion or extraction and re-implantation is recommended. If a tooth with a closed apex is intruded more than 3 mm, orthodontic or surgical repositioning should be performed within three weeks. The risk with all intrusions is that the intruded tooth may ankylose in the infraposition.

Once that begins, the tooth may not be movable except possibly surgically. It is well to advise the patient and the parents/guardians that the long-term prognosis of an intruded tooth is unpredictable, as it is likely to eventually be lost due to ankylosis.[19-21]
Splinting of a luxated tooth is recommended only for teeth that are still mobile after repositioning. In all types of trauma cases, a splint must allow for physiological movement.[22,23] (See Figs. 4a–c & 5, and Table 3, regarding splinting time.)
When assessing luxation trauma, it is important to consider the maturity of the apex. If it is still open, there is a chance that the pulp will survive the trauma or revascularize, allowing the growth of the tooth to continue (Figs. 6a–c).
If the apex is closed, endodontic treatment is likely needed. It is advisable to follow the patient closely (Table 1) or refer him or her to an endodontist for further evaluation. Because of the injury to the PDL, rapid inflammatory root resorption can occur (within days or a few weeks) if the necrotic pulpal tissue becomes infected. For mature teeth diagnosed with necrotic pulps, placing calcium hydroxide for two to four weeks prior to obturation is recommended; however, one should allow the PDL to heal for two weeks before placement (see treatment for avulsion, below). Apexification or revascularization is recommended for teeth with open apices.[24,25]

It is important to remember that dental injuries do not always fall into one group or category, but often a combination of several categories. Injuries in multiple categories will impact the outcome. For example, it was recently demonstrated that the existence of a concurrent luxation injury with an uncomplicated crown fracture and complete root development are significant risk factors of pulp necrosis.[26]

Avulsion

The time outside of the socket for an avulsed tooth is the most critical of its survival. If the tooth is replanted within 30 minutes, or alternatively kept in a physiological solution of specialized media or milk for a few hours, it has a fairly good prognosis.[27,28] If the tooth has been dry for more than one hour, the periodontal ligament cannot be expected to survive and the tooth will likely become ankylosed (Fig. 7). Once reimplanted, most teeth need to be stabilized with a physiological splint for two weeks.[29]
If the avulsed tooth has an open apex and was reimplanted within the hour, there is a possibility that the pulp will revascularize. In this case, delaying endodontic treatment at the emergency stage is recommended.

Endodontic treatment should be performed later only if signs of pul-

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Table 2. Follow-Up Procedures for Luxated Permanent Teeth

TIME	Concussion/Subluxation	Extrusion	Lateral Luxation	Intrusion
2 Weeks	Splint removal (if applied for subluxation) Clinical and radiographic examination	Splint removal Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
4 Weeks	Clinical and radiographic examination	Clinical and radiographic examination	Splint removal Clinical and radiographic examination	Splint removal Clinical and radiographic examination
6-8 Weeks	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic control
6 Months	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
1 Year	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
2-5 Years	Yearly up to 5 years	Yearly up to 5 years	Yearly up to 5 years	Yearly up to 5 years

Table 3. Splinting Time for Various Types of Injuries

Type of Injury	Splinting Time
Subluxation	2 weeks
Extrusive luxation	2 weeks
Avulsion	2 weeks
Lateral luxation	2 weeks
Intrusion	4 weeks
Root fracture (middle 1/3)	4 weeks
Alveolar fracture	4 weeks
Root fracture (cervical 1/3)	4 months

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Minimally invasive implant placement without the use of biomaterials using the bone expansion technique

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By Dr Gilles Chaumanet, France

The success rate in implantology is close to 96 percent. Thanks to well-established implant placement protocols, with a few differences according to the implant system used, the predictability of the result under optimum tissue conditions is quite significant. It is very different when these conditions do not meet the recognized standards in terms of volume and quality for reproducibility in implantology. For example, thin ridges, which are frequent occurrences, will require a long and costly process for patients because they entail bone augmentation or possibly support tissue grafts.

Is there a minimally invasive alternative for these patients that allows them to be treated without these problems? One line of thinking is to stop the systematic practice of implantology as subtractive at the tissue level, but rather to transfer these volumes and thereby ensure a minimally invasive procedure. This implies reviewing all the biomechanical principles of implantology, not only in terms of the implant structure and design but also in relation to peri-implant tissue.

The general surgical principle of modern implantology since Brånemark has been bone preparation, called osteotomy, as close as possible to the dimensions of the implant that will be placed. This principle is still widely prevalent.

However, soft-tissue management has evolved, and the trend the past few years has been to manage soft tissue from the first surgical step. With the arrival of self-tapping conical implants, a new technique was developed that enables lateral as well as vertical bone compressing, condensing or expanding. In addition, in 1994, Summers, practicing his crestal sinus lift technique with careful choice of conical taps, was the first to demonstrate the capacity of cancellous bone to be modeled (Fig.1).

Through two clinical cases, we will see it is possible to be minimally invasive, precise and also avoid the use of biomaterials simply by exploiting the biomechanical properties of bone tissue and its capacity to regenerate. Respecting guided regeneration principles, which means the implementation of physical barriers to isolate the epithelial and connective tissue cells from the operating site, enables regeneration of the different tissues.

These principles are (Fig. 2):
• Primary closure of the surgical site to enable undisturbed and uninterrupted healing.
• Completion of the best possible angiogenesis to provide the required vascularisation and undifferentiated mesenchymal cells.
• Creation and maintenance of a space to facilitate bone formation inside this space.
• Stabilization of the surgical site to induce blood clot formation and facilitate healing.

Thanks to the careful choice of the healing screw or the implant abutment/temporary crown pair, these two entities with different regeneration potentials can be hermetically sealed, thereby avoiding cell competition, which we know contributes to the growth of epithelial cells which develop more rapidly.

Case 1

The patient presented with a fracture of #16 (Fig. 3) and periapical cysts. With the patient's consent, the decision was made to perform an extraction, debridement, socket decontamination and immediate placement of a non-submerged implant (implant and healing screw) using Summers' method (crestal sinus lift). The patient was started on standard premedication with amoxicillin and corticosteroids.

The #16 was carefully extracted by radicular separation to avoid bone fracture especially in the vestibule where the cortical bone is very thin. The lamina dura, which enables the attachment of collagen and Sharpey's fibres, presents a high potential for contamination. Consequently, a light manual curettage of the socket was carried out, followed by a superficial debridement (vaporisation) of the entire "lamina dura" with an Erbium laser (2,870 nm) followed by decontamination with a diode laser (940 nm).

This was a flapless surgery. The expansion osteotomy was performed through the inter-radicular septum. It was initiated with a very thin manual bone tap (pointed) and then an automatic mechanical osteotome (Figs. 4-5) (Osteo Safe®-Anthogyr) was used. The use of convex inserts in the beginning enables lateral expansion of the native or healed bone and then concave inserts during the breaking of the last sub-sinus millimeter, enables lateral bone recovery of this bone socket while projecting it apically.

During sinus progression PRF membranes (or native collagen membranes) are placed in the osteotomy opening to fill the intra-sinus space that is thereby gained (they also provide protection of the sinus membrane).

The Erbium laser is again passed through the osteotomy socket to vaporize the bone debris and sludge along the walls of this osteotomy. The implant is placed according to the manufacturer's recommendations but with an even slightly higher torque if the titanium grade so allows. A healing screw that fits the diameter and height of the residual gap to be closed is carefully chosen (Fig. 6).

If the healing screw does not enable primary closure of soft tissue, PRF membranes are used to fill the gap. If this gap is too big, a mucoperiosteal detachment of 6-10 mm and then a horizontal incision of the periostium of 6-8 mm are made. This technique serves to pull the gum around the healing screw by maintaining it with two sutures. The control X-rays clearly showed good osseointegration of the implant, significant filling and regeneration in only three months, and then perfect filling and regeneration four months after surgery.

The bone remodeling around and above the implant neck also seemed

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Fig. 1. Original explanatory sketch of Summers' technique.

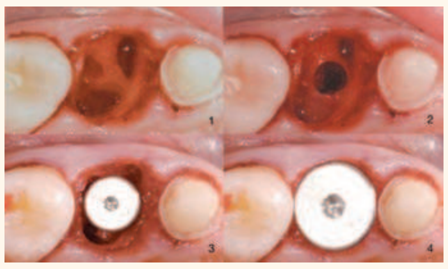

Fig. 2. Bone expansion through the septum with the use of osteotomes (a, b). Choice of healing screw that enables primary closure of soft tissue (c,d).

Fig. 3. Preoperative clinical view of #16 fractured and infected

Fig. 4. Use of OsteoSafe

Fig. 5. Complete OsteoSafe Kit

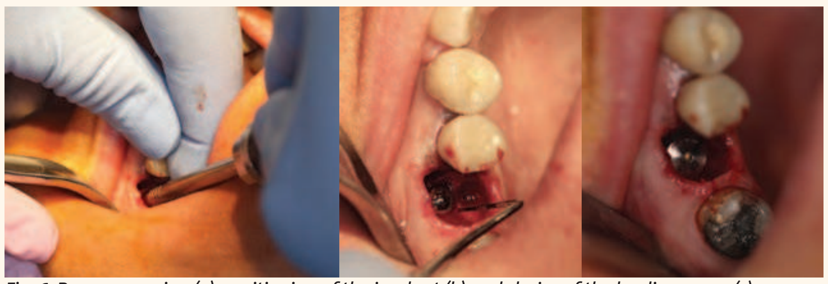

Fig. 6. Bone expansion (a), positioning of the implant (b) and choice of the healing screw (c)

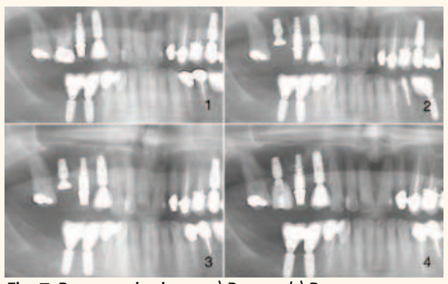

Fig. 7. Panoramic views: a) Pre-op. b) Per-op., c) at three months, d) follow-up at one year.

Fig. 8. Control at six months

Fig. 9. Preoperative view of Fistula on 24

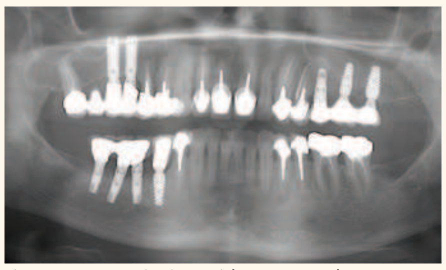

Fig. 10. Panoramic view with Gutta-Percha cone inserted in the fistula that reaches the apex

Fig. 11. Laser decontamination

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Fig. 12. Laser degranulation

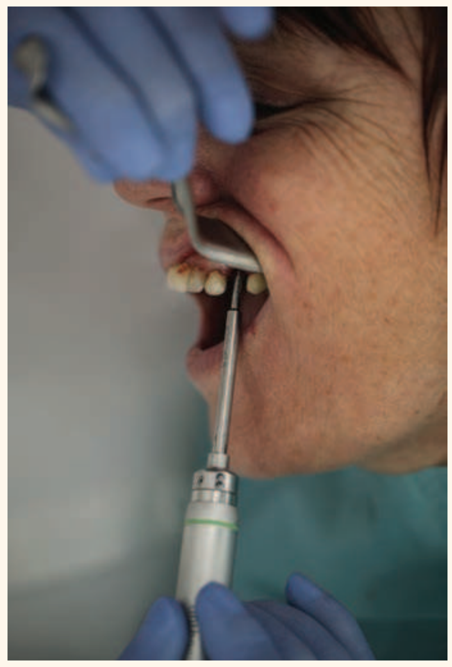

Fig. 13. Use of OsteoSafe® in the extraction socket after debridement and decontamination

Fig. 14. Positioning of the implant

Fig. 15. Immediate implant placement with temporary crown

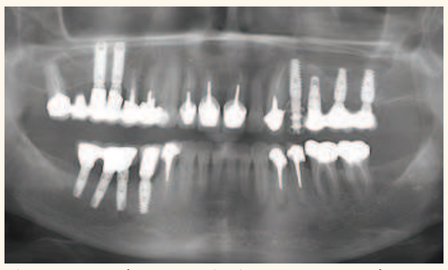

Fig. 16. Control panoramic view at two months

Fig. 17. Permanent crown at three months

to be well executed. The cone beam 3-D imaging in the first place showed a healthy sinus without inflammation or infection as well as bone remodelling at the apex and around the implant (Fig. 7-8).

In the case of a trans-alveolar sinus lift combined with the placement of an implant by bone expansion, convex-tipped inserts should be used first to enable lateral expansion, and then concave inserts enable scraping of the bones of the lateral walls of the osteotomy to enable apical projection after breaking the last millimeter under the sinus floor. If a maxillary implant is to be placed completely in native bone, convex inserts suffice. The last insert that is placed is smaller in diameter than the implant that is chosen.

The advantage of this technique was noted starting in 1996 by Summers himself with the use of conical osteotomes as opposed to cylindrical osteotomes, which were all that were available up until then. The idea was actually to enable lateral peri-implant bone condensing in order to increase notably, primary stability and compensate for the lack of vertical dimension of the sub-sinus native bone.

The objective of this technique is to maintain, if possible, the entire maxillary bone by laterally pushing back the bone with minimal trauma while creating a precise osteotomy that breaks the last millimeter of the sinus floor while protecting the sinus membrane. The consequence is the notable increase in peri-implant bone density with a high elevation of BIC (Bone Implant Contact) and, therefore, bone stability.

Case 2

The patient presented with a fracture of #24 with significant periapical infection (Figs. 9,10).

It was decided that an extraction would be performed with immediate placement and loading of an implant after complete decontamination of the extraction socket using lasers (Figs. 11, 12). Next, Osteo Safe® was used (Fig. 13) to enable gentle trabecular expansion and placement of a self-tapping conical implant (Axiom PX®-Anthogyr).

In this case, where bone recovery along the osteotomy walls was not necessary, only convex inserts were used. The palatal and subcrestal position of the implant is respected (Fig. 14). The gap between the implant and the vestibular cortical bone is not filled. Careful choice of the implant abutment enables an ideal emergence both in terms of hard tissue and soft tissue. The temporary crown is thereby shaped in such a way that it closes the gap by slightly compressing the marginal gum (Fig. 15).

It is mounted out of functional occlusion. Of course, the patient was advised to avoid voluntary chewing on this implant and only use local cleaning with cotton soaked in Chlorhexidine.

Following verification of the osseointegration (Fig. 16), the impression was made eight to 10 weeks after surgery, followed by placement of the permanent prosthesis (Fig. 17).

Conclusion

The implant placement technique with the use of osteotomes is not a new concept. On the other hand, using an automatic osteotome provides a better view of the site and makes it possible to practice flapless surgery, to position more precisely and obtain more homogeneous progression, in comparison to using bone taps with a surgical mallet. From the patient's perspective, surgical comfort is significant and very noticeable.

It should be borne in mind that if you want to avoid using filling materials, tissue must be conditioned to enable its regeneration. For immediate post-extraction implant placement, lasers are of unrivalled usefulness, because they enable socket decontamination and induce bone regeneration. If the basic principles of this bone regeneration are respected, the conditions are adequate enough to enable bone growth without the use of biomaterials.

These advantages are decisive during preparations such as alveolar sinus lift as well as "split crest" where the buccal cortical bone is generally very fragile.

Vital importance is attributed to the closure of soft tissue during implant placement, either by carefully choosing the healing screw (the height and diameter) or the implant abutment, enabling slight compression of soft tissue and providing the implant/prosthetic connection system with a 'barrier' that enables the regeneration of the two families of tissues.

These minimally invasive techniques still require many improvements and more wide-spread validation. However, for ethical and safety reasons, the practitioner should always suggest the least invasive technique that contributes to, guides and induces this tissue regeneration for which, most of the time, we have the matrix around these traumatized zones.

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Editorial note: The full list of references are available from the publisher.

Dr Gilles Chaumanet
Dr. Gilles Chaumanet graduated from the University of Nantes in 1983. He has worked in more than 15 different countries on four continents.
Since 2000, the practice of laser in his field has revolutionised his procedures. His practice is limited to oral surgery and implantology in Paris and Verona, Italy.
He holds different masters and post-graduates in laser, periodontology, implant therapy, oral surgery, anatomy and radiology. He is president of SOLA France (Society for Oral Laser Application), ambassador of Global Oral Implant Academy (GOIA), active member of CENALOS, member of French Society of Medical Laser (SFLM), member of International Academy of Periodontology (IAP), member of Italian Society of Oral Surgery (SICO) and member of AGLZ Academy. He lectures widely in Europe, America and the Middle East. He is in private practice in Villeneuve-Loubet (France) and Verona (Italy).
Visit www.drchaumanet.com.

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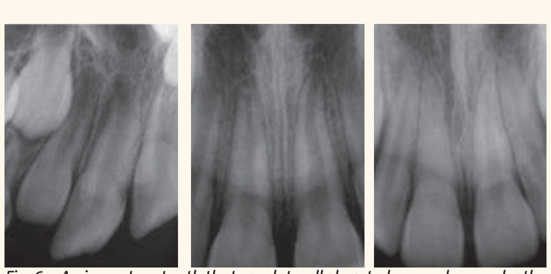

Fig. 6a: An immature tooth that was laterally luxated, as can be seen by the empty socket space around the apex on the radiograph.
Fig. 6b: The tooth was repositioned and splinted for two weeks.
Fig. 6c: At the six-month recall there is good evidence that the apex is maturing and the pulp responds normally to cold. At the three-year recall the pulp chamber is completely calcified; however, the tooth responds normally to EPT and there is no apical pathology.

Fig. 7: Ankylosis or replacement root resorption, in which the root structure is lost and replaced by bone. Note that no apparent PDL space is seen.

Fig. 8a: Inflammatory root resorption secondary to pulpal necrosis and infection in the pulpal space after avulsion. If diagnosed in time, it is possible to arrest the root resorption and maintain the tooth. Extensive inflammatory root resorption on a tooth that was avulsed and reimplanted, but no further treatment done for six weeks.
Fig. 8b_Calcium hydroxide was placed in the tooth for three months. Apparent healing of the peri-root lesions and some reconstitution of a normal looking PDL.

pal necrosis, root resorption and/or arrested root development are confirmed.

In the case of a closed apex, revascularization is not expected. Therefore, endodontic treatment must be initiated two weeks after the tooth is reimplanted, and prior to removal of the splint. Treatment should not be initiated earlier because any further manipulation of the tooth prior to or immediately after reimplantation can cause further damage to the PDL. In addition, it has been shown that placing calcium hydroxide as an intracanal medicament immediately after reimplantation will promote inflammation that can lead to PDL damage.[30] If the tooth had been kept dry longer than 60 minutes, performing root canal treatment prior to replantation is indicated.[31]

After the emergency situation has been managed and the tooth/teeth stabilized, the second phase begins, in which the pulpal condition and likelihood of root resorption have to be carefully evaluated and the patient followed over a period of months, if not years.

A follow-up timeline is essential to allow for intervention if signs of complications appear. In such cases, the expertise and training of endodontists become important. Diagnosing, preventing and treating any pulpal complications are an integral part of endodontic training as are performing pulp regenerative procedures and treating inflammatory root resorption (Figs. 8a & b).

Conclusion

Traumatic dental injuries present difficult challenges for both patients and their dentists. Current evidence allows the dental health care provider to manage situations that, in the past, often resulted in crippled dentition and unsightly appearance. Appropriate treatment can turn what at first glance looks like a hopeless situation into a very satisfactory outcome for patients. The endodontic specialist can play an important role in the team approach to treating patients with traumatic dental injuries.

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Asgeir Sigurdsson, DDS,MS
He was a full-time faculty member at UNC School of Dentistry from 1992 until 2004, first as an assistant professor and then associate professor with tenure beginning in 2000. He was appointed as the graduate program director of endodontics (specialty training) in 1997 and served in that position until 2004. From 2004 to 2012 he was in a private endodontic practice in Reykjavik, Iceland, and London, England.

He is active in many professional organizations and is past president of the International Association for Dental Traumatology (IADT). He received the Edward M. Osetek Educator Award from the American Association of Endodontists in 1998.