Reattachment and build-up of fractured maxillary central incisors

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Fig. 1

Fig. 2

Fig. 3

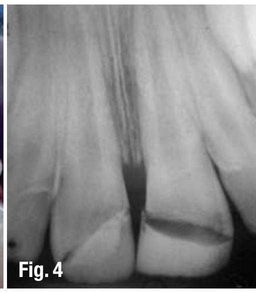

Fig. 4

Fig. 1_Dento-facial view, showing immediate treatment of the two maxillary central incisors, following a sporting accident.
Fig. 2_Pre-op status, showing extensive plaque deposits, acute gingivitis, reattachment of the coronal fragment on the right central incisor and a defective composite build-up on the left central incisor.
Fig. 3_Incisal pre-op view, showing the reattached right fragment on the right central incisor and an over-contoured composite build-up on the left central incisor.
Fig. 4_Peri-apical radiograph, showing large defects between the composite resin fillings and remaining tooth substrate, with large pulp chambers and immature, open apices.
Figs. 5–7_Post-scaling and polishing, showing improvement of gingival

_Acute dental trauma of anterior teeth is a common occurrence in children under the age of 12. The most frequently fractured teeth are the maxillary incisors, involving solely enamel, enamel and dentine or, in extreme cases, pulpal exposure, very often without root fractures. Unlike the relatively slow tooth loss due to dental caries or tooth wear, acute dental trauma is an immediate, often painful loss of natural tooth substrate. Furthermore, involvement of the pulp complicates initial and long-term treatment, placing the affected teeth in jeopardy and requiring periodic monitoring.

The sequential treatment strategy for acute dental trauma is restoring health (H), followed by function (F) and lastly, achieving acceptable aesthetics (A; the HFA triad). Contemporary dental composites and direct adhesive techniques allow replication of the tooth morphology, as well as optical (colour, translucency, opalescence, fluorescence) and mechanical properties. The advantage of a direct approach is that it is minimally invasive, not requiring additional removal of tooth substrate; however, it is technique sensitive, requiring patience and meticulous execution.

_Clinical case

A ten-year-old boy was involved in a sporting accident that resulted in acute dental trauma to the maxillary central incisors. The fractured fragment of the left central incisor was lost, while that on the right central incisor was located. The patient was treated at the accident and emergency department of a local hospital, where tetanus inoculation was verified and composite resin used to reattach the right central incisor fragment and to build-up the left central incisor (Figs. 1–3).

The patient presented to my practice a few weeks later, complaining of poor aesthetics and

Fig. 5

Fig. 6

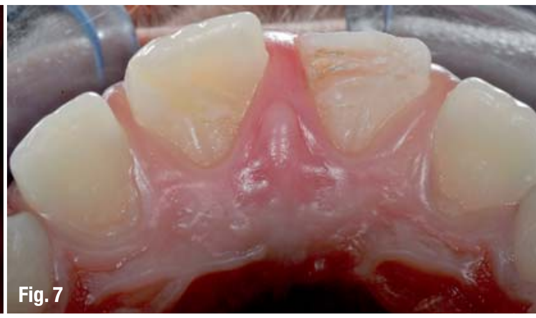

Fig. 7


Fig. 8


Fig. 9


Fig. 10

a dull ache in the buccal sulcus above the left central incisor. Intra-oral examination revealed poor contours of the composite fillings, with incorrect colour and texture. In addition, the patient's oral hygiene was unsatisfactory, with extensive plaque and calculus deposits causing acute gingivitis. The left central incisor was sensitive to gentle percussion, as well as to hot and cold stimuli.

Radiographs showed substantial defects between the composite filling and remaining tooth substrate, allowing ingress of oral pathogens (Fig. 4). The periodontal ligament was intact, no root fractures were evident and a typical solid cortical bone appearance, consistent with an acute dental trauma, was apparent.

_Initial therapy

Before considering definitive treatment, the initial items requiring attention are the periodontal and endodontic status. Assessing the endodontic condition following acute trauma is essential for treatment planning. Following an accident, the patient is distressed, anxious and mentally traumatised. In addition, the shock of the physical trauma often results in a transient anaesthesia or paraesthesia of the pulpal neural fibres.

For these reasons, assessing pulp vitality with thermal or electrical stimuli, which are highly subjective, yields unreliable results. In addition, a false-negative result is often obtained with traumatised teeth owing to the transient paraesthesia of nerve fibres. Conversely, a false-positive result is elicited when necrosis of the pulpal vascular tissues has occurred, leaving vital nerve fibres, which are more resilient. This may delay diagnosis and treatment of the affected tooth, often leading to root absorption.

A reliable and objective method for determining pulp vitality is pulse oximetry. Pulse oximetry measures the blood oxygen saturation levels or circulation within the pulp. The pulse oximeter consists of light-emitting diodes (LED) of two wavelengths (red light – 640 nm and infrared light – 940 nm) and a receptor for recording the spectral absorbance of the oxygenated and deoxygenated haemoglobin in the tooth pulp. A computer calculates the percentage of oxygen saturation levels, which is approximately 75 to 80 % for vital teeth, compared to values at the fingers or ear lobes of 98 %. The tooth oxygen saturation levels are lower than soft tissues of the body owing to the dentine and enamel, which scatters the LED light. A reading of 78 % was obtained for this patient, indicating that there was adequate vascularity for eventual regeneration of the pulp. At this stage, root-canal therapy was not necessary.

In order to resolve the acute gingivitis, the teeth were scaled and polished, and the patient counselled about home oral-hygiene procedures. Impressions for the diagnostic wax-up were delayed until gingival health had improved.

health and detachment of the defective composite build-up on the left central incisor. Notice the clearly visible dentine mamelons and incisal edge lobes of the reattached fragment on the right central incisor.

Fig. 8_Dento-facial view with VITA Classic shade guide.

Fig. 9_Dento-facial view with VITA 3D Shade Guide.

Fig. 10_Photograph of patient before the sporting injury. Notice the blatant maxillary midline diastema.

Fig. 11_A large overjet of 7 mm, making the maxillary incisors vulnerable to external trauma.

Fig. 12_Facial view of pre-op plaster model.

Fig. 13_Incisal view of pre-op plaster model.

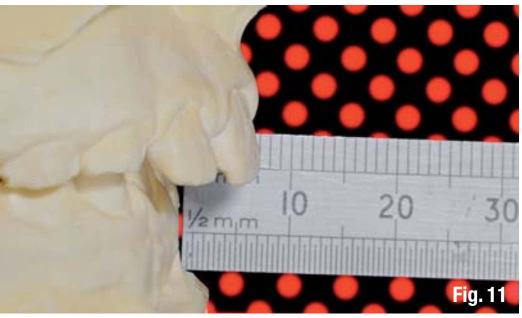

Fig. 11

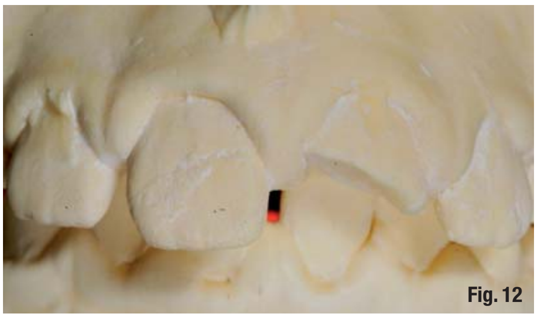
Fig. 12


Fig. 13


Fig. 14


Fig. 15


Fig. 16

Fig. 14_Facial view of diagnostic wax-up.
Fig. 15_Right lateral view of diagnostic wax-up.
Fig. 16_Left lateral view of diagnostic wax-up.

_Diagnostic wax-up and silicone index

At the next appointment the following week, the gingivitis had resolved but the composite build-up on the left central incisor had detached from the remaining tooth substrate (Figs. 5–7). In order to prevent sensitivity and bacterial invasion, the exposed dentine on the left central incisor was etched with 37 % phosphoric acid for 20 seconds and immediately sealed with a dentine-bonding agent (OptiBond Solo Plus, Kerr). The gingival condition had improved following prophylaxis and oral-hygiene instruction, and upper and lower impressions were taken using an accurate, soft, distortion-free material (AlgiNot FS, Kerr). Concurrently, reference photographs were taken with VITA Classic and VITA 3D Shade Guides (VITA) for shade analysis (Figs. 8 & 9).

The impressions were cast with hard plaster for the diagnostic wax-up. The patient was asked to supply photographs of his teeth prior to the accident (Fig. 10), which are an invaluable guide for assessing tooth anatomy and for guiding the dental technician during the wax-up process. The patient displayed a large overjet of 7 mm, which obviously places the central incisors in a precarious situation, highly susceptible to traumatic injury (Fig. 11).

In the dental laboratory, the preoperative models of the fractured incisors were waxed-up to the proposed facial and palatal morphology (Figs. 12–17). An index was fabricated, using a heavy body, addition silicone impression material and sectioned at the incisal edge, ensuring that a ledge was present at the incisal edge to support the intra-oral composite build-up (Figs. 18 & 19).

_Composite build-up on the left central incisor

Choice of composite

The two basic criteria for selecting an appropriate composite filling material are satisfaction of function (resilience, mechanical and thermal properties) and aesthetics (replicating enamel, dentine and characteristics such as translucency, opalescence and fluorescence). In this instance, the new Herculite XRV Ultra (Kerr) was chosen for its superior mechanical and optical properties. Herculite XRV Ultra is a nano-hybrid composite, updated from its predecessor Herculite XRV, which was introduced over two decades ago.

The endearing feature of nano-composites is the very small particle size of the filer, 25 to 75 nm smaller than in micro-hybrids. The reduced filler size particles confers superior aesthetics by allowing excellent surface gloss after polishing, as well as advantageous optical properties, such as opalescence and fluorescence. In addition, Herculite XRV Ultra offers favourable wear resistance, compressive strength, fracture toughness and flexural strength with good adaptability, sculptability and thixotropic properties. Furthermore, it is available in a large range of enamel, dentine and incisal shades for

Fig. 17_Incisal view of diagnostic wax-up.
Fig. 18_Facial view of diagnostic wax-up with silicone index *in situ*.
Fig. 19_Facial view of diagnostic wax-up and palatal aspect of silicone index, showing the palatal anatomy with incisal ledge to support the intra-oral composite build-up.


Fig. 17


Fig. 18


Fig. 19


Fig. 20


Fig. 21


Fig. 22

incremental layering or stratification placement. The latter techniques are commonly utilised to reduce polymerisation stresses by lowering the C-factor and for emulating the shade nuances and characterisations within natural teeth, for example incisal halos, mamelons and translucencies.

Clinical technique

After two weeks, the symptoms associated with the left central incisor had subsided (that is, sensitivity and buccal tenderness), and no response was elicited with gentle percussion.

In addition to the preoperative colour analysis with shade tabs carried out earlier, small beads of Herculite XRV Ultra shades Incisal, Enamel A1, and Dentine A2 were directly placed on the tooth and light-cured to ensure a precise shade match (Fig. 20). This method allows a direct comparison of set composite on the natural tooth substrate and is an excellent method for selecting the correct enamel and dentine shades of composite. Next, the silicone index was placed against the teeth to confirm correct location and exact seating (Fig. 21).

Isolation is essential for composite resin fillings to accomplish a moisture-free environment. Various methods are available, including gingival retraction cords, cotton wool rolls, aspiration and a rubber dam. Several techniques are advocated for rubber dam use, including complete isolation of individual teeth (Fig. 22) and the split-dam technique for isolating a number of teeth (Fig. 23). However, when building-up anterior teeth, for which aesthetics is of paramount concern, using a rubber dam can be disadvantageous owing to excessive dehydration of teeth, making accurate shade assessment challenging. Therefore, for this patient, a dry retraction cord was carefully eased into the gingival sulcus to absorb the crevicular fluid, together with cotton wool rolls in the sulci and continuous aspiration to maintain a dry field. This protocol prevented desiccation of the teeth, allowing a precise shade assessment during the layering placement of the composite build-up.

After composite shade selection, silicone index verification and tooth isolation, the tooth was prepared for resin build-up. The reattached fragment on the right central incisor was left untouched and served as a guide to mimic shape, colour and characterisations of the build-up on the left central incisor (Fig. 20). Several designs are suggested for preparing the tooth substrate, including no preparation, simple chamfer or the stair-step chamfer. In this instance, a simple 1 mm chamber was created on the buccal and lingual surfaces using a tapered round-ended diamond bur (Fig. 24). The prepared tooth was etched with phosphoric acid and dried (not desiccated), and OptiBond Solo Plus was applied according to the manufacturer's instructions (Figs. 25 & 26). The stages for the layered composite build-up are as follows:

_Step 1: Using the CompoRoller (KerrHawe SA), a thin layer (1 to 1.5 mm) of Herculite XRV Ultra

Fig. 20_Beads of different shades of Herculite XRV Ultra (Kerr) placed and set directly onto the left central incisor (from left: Incisal, Enamel A1, Dentine A2 shades).
Fig. 21_Silicone index placed onto placed surfaces of incisors to ensure correct seating.
Fig. 22_Complete isolation of each tooth with a rubber dam.

Fig. 23_Split-dam technique used to isolate the anterior maxillary sextant.
Fig. 24_A 1 mm chamfer being prepared around the circumference edge of the fracture. Notice the visible gingival retraction cord on the mesial aspect.
Fig. 25_Enchant is applied for 20 seconds using the total etch technique.


Fig. 23


Fig. 24


Fig. 25


Fig. 26

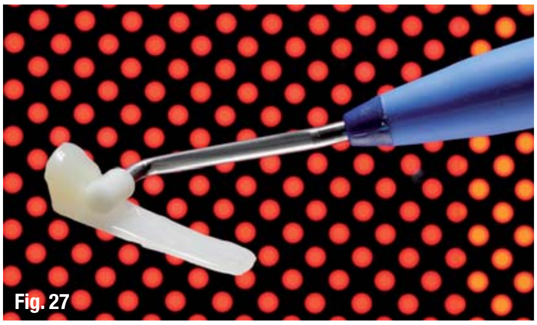
Fig. 27


Fig. 28

Fig. 26_Dentine bonding agent is applied on all surfaces and light-cured.
Figs. 27 & 28_The CompoRoller (KerrHawe) is used to form a thin layer (1 to 1.5 mm thick) of incisal shade to place into the silicone index, which is used as a template to guide placement of the palatal incisal layer and ensure the correct length of the tooth.

Incisal shade was rolled out (Fig. 27) and placed into index to build-up the palatal aspect and incisal edge, and subsequently light-cured with the index *in situ* (Fig. 28).

_Step 2: The index was removed and the palatal incisal layer inspected to ensure that it was not too thick and that sufficient space was available for the remaining layers (Fig. 29), and subsequently light-cured from the palatal aspect.
_Step 3: A thin layer of Herculite XRV Ultra Dentine A1 was placed at the incisal edge, mesial and distal aspects to re-create the incisal halo effect (Fig. 30).
_Step 4: Using a suitably shaped instrument, Dentine A2 shade was used to copy the mamelon effect of the reattached fragment on the right central incisor (Fig. 31).
_Step 5: CompoRoller tips of various shapes, for example conical and cylindrical, were used to sculpt the Enamel A1 covering layer (Figs. 32–34).
_Step 6: The reconstruction was completed with a thin covering layer (0.5 mm) of Incisal shade at the incisal third of the build-up (Fig. 35).

The final contouring and finishing were postponed for one week. This allows re-evaluation of the shade and characterisations by both the patient and clinician. Necessary changes were performed before proceeding with the finishing and polishing. Composite layering is a lengthy and painstaking process, requiring meticulous attention by the operator and protracted endurance by the patient. Both these factors contribute to tiredness and loss of concentration, and finishing and polishing after a long treatment session is inadvisable. The shade and characterisation of the build-up a week later was satisfactory, ready for adjusting morphology and finalising surface texture (Figs. 36 & 37).

_Reattachment of fractured tooth segment

The reattachment of fractured segments is a conservative approach to restoring health, function and aesthetics. It is particularly advantageous for aesthetic appearance, since the natural tooth fragment is used to restore the original morphology and colour. However, if the remaining tooth substrate has discoloured owing to breakdown of the pulpal blood vessels, there may be a colour transition between the tooth and the reattached fragment. Depending on the amount of remaining tooth, this is usually not a concern, since the cervical aspects of teeth are darker than the incisal aspects.

Clinical technique

The procedure for reattaching a fragment is similar to a free-hand composite build-up but with the following differences. Firstly, the colour transition of the sandwiched composite between the remaining tooth and reattached fragment should be a seamless. Secondly, to improve the fracture strength of the repaired complex (remaining tooth/composite/fragment), it is advisable to re-hydrate the fragment for at least 30 minutes prior to bonding with the resin composite. The sequence was as follows:

Fig. 29_Silicone index removed, showing the initial build-up layer.
Fig. 30_A thin layer of dentine shade is placed at the mesial, incisal and distal edges to simulate an incisal halo.
Fig. 31_A rounded conical-shaped hand instrument is used to create dentine mamelons.


Fig. 29


Fig. 30


Fig. 31


Fig. 32


Fig. 33


Fig. 34

Fig. 32_The CompoRoller with a conical tip is used to sculpt the surface anatomy.

Fig. 33_The CompoRoller with a cylindrical tip is used to sculpt the surface anatomy.

Fig. 34_The dentine mamelon effect created by using a dentine shade is clearly visible at the mesial aspect before being covered with an enamel shade overlay.

_Step 1: The fractured fragment was carefully removed without damaging the remaining tooth or the fragment (Fig. 38) and hydrated in sterile water for 30 minutes.
_Step 2: The silicone index was placed onto the teeth and aided the correct location of the dislodged fragment (Fig. 39).
_Step 3: The retraction cord was placed around the right central incisor, and both the remaining tooth and fragment were etched and coated with OptiBond Solo Plus. A thin layer of Herculite XRV Ultra Incisal shade was placed into the index to 'link' the tooth and fragment and subsequently light-cured. The index was removed, and the position of the fragment verified from both facial and palatal aspects (Figs. 40 & 41).
_Step 4: The chasm between the tooth and fragment was filled with a combination of Dentine A2 and Enamel A2 shades to create an unnoticeable colour transition (Figs. 42 & 43).

_Finishing and polishing

The final stage of a composite filling is finishing and polishing, which ensures longevity and superior aesthetics. The finishing procedure, which ensures a high gloss and smooth surface roughness (Ra), is important not only to prevent surface discolouration, but also to ensure oral health by reducing plaque accumulation and gingival irritation. Furthermore, polishing is also beneficial for achieving good marginal adaptation, reduced micro-leakage and for retaining morphology and occlusal contacts owing to improved wear resistance. The type of inorganic filler, particle size and the degree of loading influence the polishability of a composite. Furthermore, the difference in hardness between the resin matrix and filler content and amount of conversion of the polymer also contribute to the degree of surface roughness.

Other factors affecting the finish are the flexibility and hardness of the finishing materials, force applied, speed and cooling of rotary instruments, and duration of the polishing procedure. However, contemporary light-cured composites with finer particles (for example, nano-filled) and fine grit rotary instruments allow a durable, smooth and high lustre texture to be readily attainable.

Although using cellulose acetate matrices or Mylar strips mitigates the finishing procedures, most free-hand composite build-ups usually require finishing and polishing to remove excess composite and alter morphology and occlusion. In addition, the superficial oxygen inhibition layer requires removal to improve the surface hardness of the composite for resilience and improved aesthetics. But how smooth is smooth? The degree of micromorphology irregularities to which a filling should be finished is debatable. Some authorities suggest that the microscopic surface irregularities should be smaller than the critical bacterial adhesion threshold of Ra = 0.2 µm, while others state that it should equal the Ra of natural enamel-to-enamel occluding surfaces. Another threshold for smoothness is that in order for a filling surface to appear smooth optically, its Ra value should be less than

Fig. 35_The completed reconstruction with a thin overlying incisal shade at the incisal third of the build-up.

Fig. 36_A week later, the colour of the build-up on the left central incisor is acceptable and ready for finishing and polishing.

Fig. 37_Incisal view of the build-up on the left central incisor, one week later. (The cervical gingival margin of the left central incisor shows a trapped cornhusk, which was subsequently removed.)


Fig. 35


Fig. 36


Fig. 37

Fig. 38_Removal of the fractured segment on the right central incisor.
Fig. 39_After re-hydration, the fragment is correctly located in position with the silicone index.
Fig. 40_Facial view of the fragment secured to the existing tooth with Herculite XRV Ultra Incisal shade.

1 µm, which is similar to natural enamel surface roughness of Ra 0.3 µm to 0.5 µm.

Many methods have been advocated for finishing and polishing composite restorations, including multi-fluted (16 to 30) tungsten carbide burs, fine grit (<25 µm) diamond burs, aluminium oxide (Al_2O_3) coated abrasive discs, silicone and rubber points, felt discs with diamond paste, and unfilled resins to coat the surface layer of the restoration. The type of polishing system depends on the type of composite, the degree of contouring required for aesthetics and occlusion, and the operator's experience and familiarity with a specific finishing system.

Generally, micro-filled and nano-filled composites can be polished to a very high gross finish compared to hybrid and condensable varieties. If the contours of the restoration require extensive alteration, a diamond bur is preferable (rather than a fluted carbide) followed by silicone tips, discs and polishing pastes. Conversely, if the morphology and surface topography require little modification, the ideal starting point is with fluted carbide burs, followed by silicone tips, discs and polishing pastes. Also, condensable composites may require more abrasive instruments compared to micro-filled or nano-filled composites.

Clinical technique

The polishing system used for this case study was the Hawe Composite Surface Treatment Kit (KerrHawe SA) consisting of OptiDisc, Al_2O_3-coated inter-proximal strips (Fig. 44), fluted finishing burs, HiLuster tips, and brushes for diamond polishing paste. The sequence was as follows:

_Step 1: All rotary instruments were copiously irrigated with water at a speed not exceeding 50,000 min^{-1} and gingival retraction cord was placed around the teeth to prevent laceration of the soft tissues. Excess composite was removed and the anatomy refined with OptiDisc, starting with the black centre super coarse disc and ending with the blue centre coarse/medium disc. The discs were also used to create the incisal lobes of the build-up on the left central incisor, guided by the incisal lobes of the reattached fragment on the right central incisor.
_Step 2: The facial and palatal topography (undulations) was formed with the fluted finishing burs and polished with the HiLuster tips.
_Step 3: Inter-proximal composite excess and overhangs were smoothed with Al_2O_3-coated inter-proximal strips of varying coarseness.
_Step 4: The restoration was polished with diamond paste for a high gloss and lustre.

The finished and polished restoration demonstrates correct anatomical form; seamless colour transition between the composite build-up/reattached fragment and the remaining tooth structure; incisal lobes on the left central incisor, mimicking those of the incisal edge of the right central incisor; and correct lustre and texture (Fig. 45). The patient was supplied with

Fig. 41_Incisal view of the fragment secured to the existing tooth with Herculite XRV Ultra Incisal shade.
Fig. 42_Facial view of reattached fragment with remaining tooth substrate. Observe the seamless colour transition.
Fig. 43_Incisal view of reattached fragment with remaining tooth substrate. Observe that the cornhusk at the cervical gingival margin of the left central incisor has been removed (compare with Fig. 37).

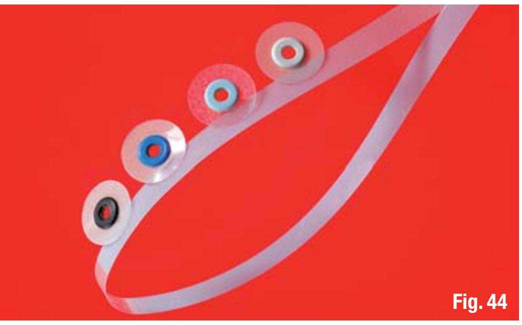

Fig. 44

Fig. 45

Fig. 46

a mouth guard and advised to attend for periodic review appointments, or earlier, if endodontic symptoms developed. In addition, oral-hygiene procedures were re-enforced.

_Post-operative results

Figures 46 to 48 demonstrate the post-operative results at two weeks. Observe the impeccable gingival health; correct anatomical form of the composite build-up on the left central incisor; a seamless transition between the composite and natural tooth substrate; dentine mamelons in the coronal build-up on the left central incisor and an incisal halo, opalescence, incisal edge translucency within the build-up on the left central incisor, mimicking the reattached natural tooth fragment on the right central incisor.

It is important to note that the composite build-up on the left central incisor is similar but not identical to the right central incisor. It is clinically difficult to produce a facsimile by direct free-hand composite build-up, and it is unusual to find identical teeth in any one individual dentition, and slavishly copying an existing tooth appears contrived and artificial, which is rarely observed in nature. Nature is creative, rather than perfect. Finally, any artificial prostheses or restoration should broadly conform to the existing dentition by blending with the surrounding teeth.

The full-face images show restitution of dental aesthetics that are in harmony with the surrounding lips (Figs. 49 & 50).

_Conclusion

Acute dental trauma is distressing for the patient and challenging for the clinician. Following initial emergency treatment to alleviate pain and sepsis, the goal is salvaging as much natural tooth as possible. The restoration of health, function and aesthetics is achievable with direct composite restorations and is less destructive than many indirect approaches that remove additional tooth substrate, which further compromises the damaged tooth. The free-hand build-up, guided by a silicone index, is conservative and minimally invasive, but requires a degree of patience and expertise of the operator, and endurance of lengthy appointments by the patient. Salvaged and usable fragments of fractured teeth are ideal for reconstructing teeth to their former morphology and aesthetics._

Fig. 47

Fig. 48

Fig. 49

Fig. 50

_contact cosmetic dentistry

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Fig. 44_OptiDiscs of varying coarseness with an inter-proximal strip.
Fig. 45_The finished and polished restorations, showing correct anatomy and surface texture, as well as seamless transition between the remaining tooth and composite fillings.
Fig. 46_Post-op facial view (compare with Figs. 2 & 5).
Fig. 47_Post-op incisal view (compare with Figs. 3 & 7).
Fig. 48_Post-op dento-facial view (compare with Fig. 1).
Fig. 49_Pre-op full-face view.
Fig. 50_Post-op full-face view.