J Korean Acad Pediatr Dent 43(1) 2016
ISSN (print) 1226-8496 ISSN (online) 2288-3819
http://dx.doi.org/10.5933/JKAPD.2016.43.1.60

Esthetic Restoration of Complicated Crown-Root Fractures Utilizing Orthodontic Extrusion

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Abstract

Complicated crown-root fracture of permanent incisors cause esthetic, functional, and psychological problems to patients. Therefore, treatment is important and multidisciplinary treatment is required.

This case report describes the clinical procedures involved in the treatment of trauma-induced complicated crown-root fractures in the maxillary incisor of two young patients. Conventional root canal treatment and apexification were performed in each patient. To expose the fracture margins to the supragingival level and to reestablish the biologic width, orthodontic extrusions with fixed appliances were performed followed by a retention period. During the retention period, fiber-optic posts and cores were built up and provisional crowns were placed. Finally, ceramic crowns manufactured using a computer-aided design/computer-aided manufacturing (CAD/CAM) system were placed.

In both patients, the teeth presented satisfactory functional and esthetic outcomes without relapse. The periodontal tissues were healthy.

Key words : Complicated crown-root fracture, Maxillary incisors, Orthodontic extrusion, Esthetic restoration

Ⅰ. Introduction

A crown-root fracture is a type of dental trauma occurring below the gingival margin that involves enamel, dentin and cementum. It may be classified as complicated or uncomplicated, depending on whether the pulp is involved[1]. Epidemiological studies reveal that crown-root fractures represent 5% of dental injuries, and most of these injuries occur in permanent maxillary incisors[1-3]. Fractures of these teeth can cause esthetic, functional, and psychological problems for the patient[2]. Therefore, treatment of complicated crown-root fractures is important but often challenging especially when the biologic width has been violated. In complex cases, combinations of endodontic, orthodontic, periodontal, and restorative procedure may be required[1-3]. For instance, if complicated crown-root fracture occurred to the patient who has crowding in the anterior teeth, the final restoration of fractured tooth should be done after orthodontic treatment of crowding ideally. However, the treatment plan can be modified depending on the patient's conditions.

This report describes the multidisciplinary treatment of complicated crown-root fractures in two young patients with favorable clinical results.

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Received December 24, 2014 / Revised February 16, 2015 / Accepted February 12, 2015

Ⅱ. Case Reports

1. Case 1

A 12-year-old male reported an accident during school activity 2 hours before, which resulted in fracture of maxillary right central incisor. The patient had no specific medical history. Clinical examination revealed an oblique crown-root fracture of maxillary right central incisor with the fracture line extending subgingivally at the palatal aspect (Fig. 1). The fractured coronal segment was already detached and the pulp was exposed. The tooth had no mobility and no sensitivity to percussion. Radiographic examination confirmed the findings of the clinical examination; the fracture line on the palatal side could be traced about 1 mm below the alveolar crest and the root apex was closed (Fig. 2). There was no damage to adjacent teeth or other facial bones (Fig. 3).

Fig. 1. Intraoral views showing fractured maxillary right central incisor. (A) Facial view. (B) Occlusal view.

On the basis of clinical and radiographic findings, a diagnosis of complicated crown-root fracture was made. A definitive treatment plan was developed to include a root canal treatment and post-retained crown along with orthodontic extrusion to move the fracture line 3 mm above the alveolar crest. This would restore the lost biologic width and allow sufficient tooth area available for core build-up and crown preparation.

In the first stage of treatment, a conventional root canal treatment was performed (Fig. 4). Brackets were bonded to the adjacent teeth, a temporary intracanal post was placed and extrusive force was provided to the post by an elastic thread (Fig. 5). To achieve tooth extrusion without alteration of gingiva level, rapid extrusion was planned. The aimed extrusion force was approximately 80 - 100 mg and the force was measured by a force gauge. After 2 weeks, 1 mm of extrusion was achieved. However, several problems such as elastic thread snap, discomfort of tooth, and difficulty in controlling the direction and amount of force occurred. Therefore the design of extrusion was changed.

Fig. 2. Preoperative periapical view showing the extent of fracture and closure of the root apex.

Fig. 3. Preoperative panoramic view. No damage was found in the adjacent teeth and other facial bones.

Fig. 4. Periapical view after conventional root canal treatment.

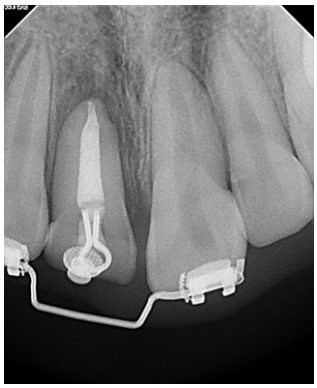

Fig. 5. Temporary intracanal post and appliances used for orthodontic extrusion of the root fragment.

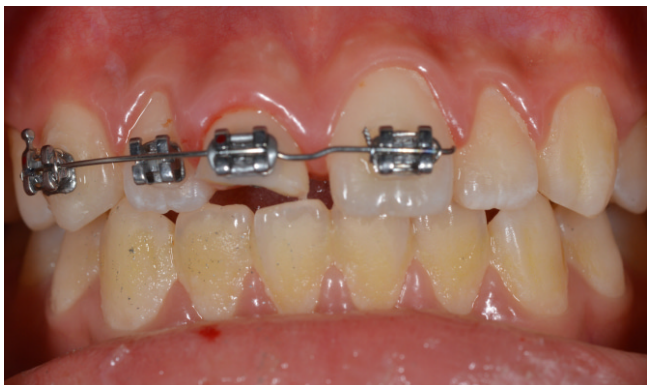

Fig. 6. Intraoral view of the orthodontic extrusion with brackets, around 4 mm of extrusion had been achieved within 6 weeks and the coronal migration of soft tissue was notable.

Fig. 7. Periapical view after 8 weeks of stabilization, showing good bony repair.

Fortunately, there was sufficient space on the labial surface of the fractured tooth to place a bracket. This new bracket was placed more gingivally on the tooth to be extruded and the extrusion force was provided by an orthodontic wire. After 6 weeks of treatment, around 4 mm of extrusion had been achieved totally (Fig. 6). The horizontal wire and brackets were removed after 8 weeks because bony and periodontal repair were evident (Fig. 7).

After then, the patient was referred to the prosthodontist. Before tooth preparation, gingivectomy was performed to correct the discrepancy of the gingival margin due to coronal migration of the soft tissue. Subsequently, a fiber-optic post (ParaPost® Taper Lux, Coltene) was cemented and a core (LuxaCore® Dual, DMG) was built up (Fig. 8). Afterwards, the tooth preparation was done and a provisional crown was placed (Fig. 9). Treatment was temporarily ceased by the patient for personal reasons. After 6 months, the patient returned to continue the remaining treatment. The provisional crown was removed and the condition of both the tooth and gingiva was found to be in good condition. A final impression was taken using an oral scanner (CEREC® Omnicam, Sirona) and an all-ceramic crown (IPS e.max® CAD, Ivoclar Vivadent) was made by computer-aided design/computer-aided manufacturing (CAD/CAM) milling machine (CEREC® MC XL, Sirona). The crown was placed and good esthetics were achieved (Fig. 10).

The patient was evaluated on subsequent visits to monitor the restoration. The tooth presented satisfactory functional and esthetic outcomes and no relapse was noted. In addition, the periodontal tissues remained healthy.

Fig. 8. Intraoral view after post and core build up.

Fig. 9. Intraoral view after provisional crown placement.

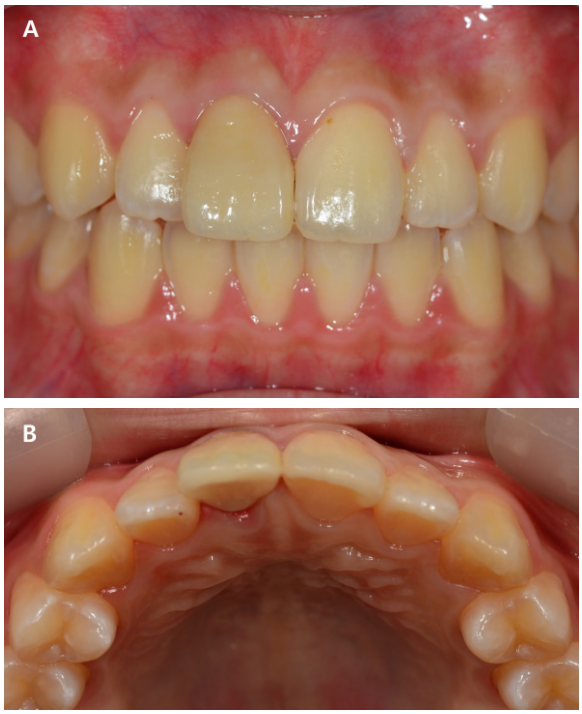

Fig. 10. Intraoral view after final restoration, good esthetics were achieved. (A) Facial view. (B) Occlusal view.

2. Case 2

A 9-year-old male reported with a chief complaint of anterior tooth fracture and a history of falling down and bumping into a corner of his bed the night before. The patient had no specific medical history. The clinical examination revealed an oblique crown-root fracture of maxillary left central incisor with the fracture line extending subgingivally at the disto-palatal aspect (Fig. 11). The coronal fragment was lost. The tooth had no mobility but presented tenderness to percussion. In addition, both lower central incisors showed slight enamel fracture on the incisal tip. Through radiographic examination, uncompleted root formation and an open apex was found; the fracture line on the palatal side was above the alveolar crest (Fig. 12). There was no damage to other facial bones (Fig. 13).

Fig. 11. Intraoral views showing fractured maxillary left central incisor. (A) Facial view. (B) Occlusal view.

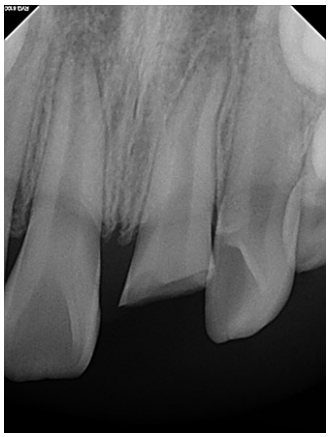

Fig. 12. Preoperative periapical view showing the extent of fracture.

Fig. 13. Preoperative panoramic view. Minor enamel fractures were found in the mandibular central incisors but no damage was found in the surrounding bone.

Fig. 14. Periapical view after MTA apexification.

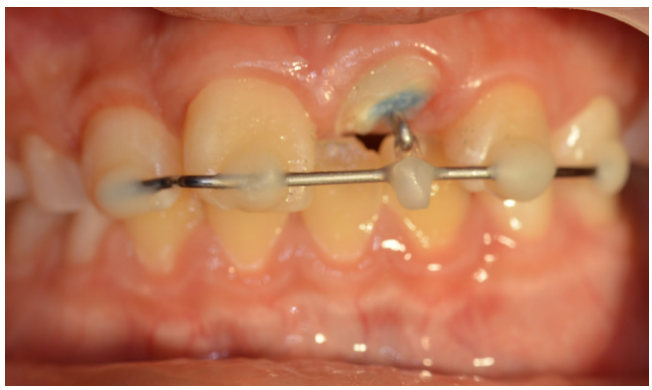

Fig. 15. Temporary intracanal post and appliances used for orthodontic extrusion of the root fragment.

On the basis of clinical and radiographic findings, a diagnosis of complicated crown-root fracture with concussion of maxillary left central incisor and enamel fracture of lower central incisors was made. For treatment, apexification with mineral trioxide aggregate (MTA) and a post-retained crown were planned. This would be followed by orthodontic extrusion to move the fracture line above the gingival margin to regain the lost biologic width and improve the retention of the prosthetic crown.

Apexification with MTA was performed in two steps. On the first day of treatment, the working length was determined by periapical radiograph. Biomechanical preparation was carried out using #80 K-file and root canal debridement was done using alternative irrigation with 2.5% NaOCl and saline. The canal was dried with paper points and MTA (Ortho MTA®, BioMTA) was placed with pluggers until to a depth of 5 mm (Fig. 14). A wet cotton pellet was placed in the canal and the access cavity was sealed with temporary cement. In the next appointment, the root canal was obturated with gutta-percha.

The orthodontic extrusion was then initiated. As there was less than 1 mm of healthy tooth structure supragingivally, it was difficult to place a bracket on the tooth. Therefore, a temporary intracanal post was placed and extrusive force was provided to the post by an elastic thread secured around the horizontal wire (Fig. 15). To achieve tooth extrusion without alteration of gingiva lev-

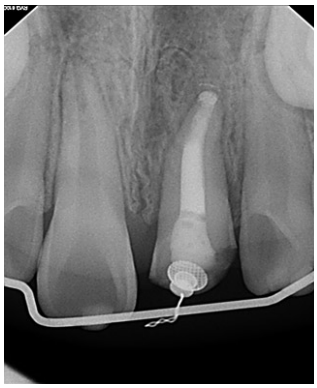

Fig. 16. Tooth stabilization after orthodontic extrusion by ligating the button and horizontal wire with ligature wire.

Fig. 17. Periapical view after 8 weeks of stabilization, showing good bony repair.

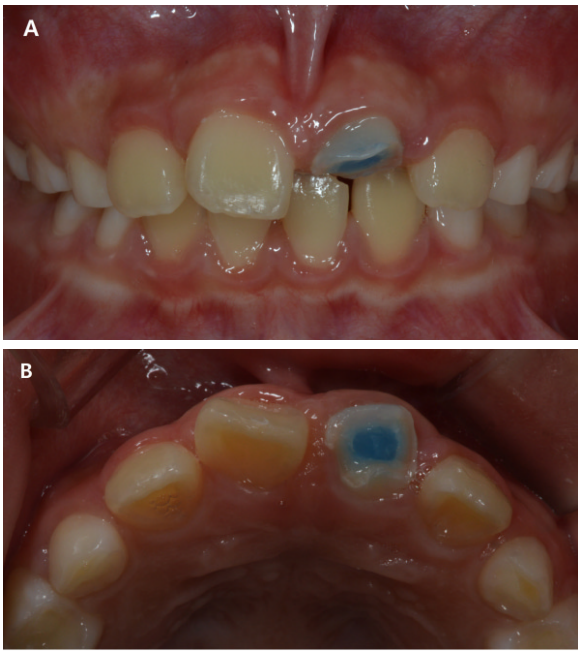

Fig. 18. Intraoral view after 8 weeks of stabilization, the fracture lines were exposed supragingivally and no coronal migration of soft tissue was found.

el, rapid extrusion was planned. The aimed extrusion force was approximately 80 - 100 mg and the force was measured by a force gauge. After 2 weeks, about 2 mm of extrusion was achieved. Although, the amount of extrusion was sufficient, the prosthodontist decided that it would be difficult to make a prosthetic crown due to the deep overbite. It was decided to move the tooth more buccally and revaluate whether it would be possible to make the prosthetic crown. After 4 weeks, around 2 mm of buccal inclination of the tooth was achieved and the prosthodontist determined that it was possible to make the prosthetic crown. The intracanal post was removed and a button was placed on the tooth instead. The tooth was stabilized for 4 weeks by ligating the button to the horizontal wire with ligature wire (Fig. 16).

After 4 weeks retention, the bony and periodontal repair was evident and the horizontal wire and button were removed (Fig. 17, 18). After then, the patient was referred to the prosthodontist. A fiber-optic post (ParaPost® Taper Lux, Coltene) was cemented and a core (LuxaCore® Dual, DMG) was built up. After the tooth preparation and a final impression with the oral scanner (CEREC® Omnicam, Sirona), a provisional crown was placed and the tooth was stabilized for an additional 4 weeks. Finally, a porcelain veneered zirconia (PFZ) crown (zirconia coping: ZirPremium® UT, Acucera, porcelain veneer: Vitablocs® MarkII, Vita Zahnfabrik) which was made by CAD/CAM milling machine (CEREC® MC XL, Sirona) was placed (Fig. 19).

Fig. 19. Intraoral view after final restoration, good esthetics were achieved. (A) Facial view. (B) Occlusal view.

Fig. 20. Follow-up radiograph showing a hard tissue barrier in the root apex.

The patient was kept on recall checks to monitor the restoration. Through periapical radiographs, formation of a hard tissue apical barrier was found (Fig. 20). The tooth showed good esthetic results and no relapse was noted. In addition, the periodontal tissues were healthy.

Ⅲ. Discussion

Complicated crown-root fractures have implications for the endodontic, periodontal, and restorative prognosis because the involved biologic width[1-3]. Therefore, the main objective of the treatments is exposing the fracture margins to the supragingival level, so that clinical procedures can be performed without contamination with blood and saliva[1,3]. If the length of the apical root is sufficient to maintain a favorable crown-root ratio (maximum 1 : 1) even after extrusion, the root can be orthodontically extruded to elevate the fracture margin supragingivally and allow for a ferrule effect[1,2]. Usually, a 3-4 mm distance from the alveolar crest to the coronal extension of the remaining tooth structure has been recommended for optimal periodontal health[4].

Orthodontic extrusion is a biological method that does not involve the loss of alveolar bone or periodontal support and produces good esthetic results[2-6]. The major limitation of this treatment is the relatively long time of treatment and long period of stabilization[6]. In addition, wearing an orthodontic appliance during treatment may cause unesthetic appearance, inconvenience, and may adversely affect oral hygiene[2]. Nevertheless, it still has many advantages when compared to surgical procedures. Extrusion is usually performed by fixed orthodontic appliances utilizing arch wires or elastics attached to the tooth, but it can also be accomplished using a removable appliance and elastics. Selecting the design of appliances depends on the clinical conditions encountered[6].

The force used in orthodontic extrusion will vary depending on the physiologic response of the patient and other factors. Continuous light forces have usually been recommended for orthodontic extrusion, however, this may cause reverse osseous architecture around the extruded tooth. Therefore, at the end of the procedure, periodontal surgeries may be necessary to correct the periodontal discrepancy with the adjacent teeth. In case of rapid extrusion, there is no need to reshape bone as coronal shift of the marginal bone does not occur[6]. Rapid extrusion has a low risk of root resorption and ankylosis[6,7]. The force may be appropriately controlled[6]. The extent of the force exerted can only be approximated, since it is difficult to quantify. The force must be adjusted on the basis of the clinically verified rate of extrusion, which is approximately 1 mm or less per week for slow extrusion[1,6]. Some authors report that the maximum force should not exceed 30 g for slow extrusion, whereas rapid extrusions need forces greater than 50 g. In fact, the safety limits are difficult to establish[6].

When a tooth is moved to a new position, the supracrestal gingival fibers tend to stretch and may become the major cause of relapse. Retention is therefore necessary to retain the root in its new position after orthodontic treatment. Although, recommendations for the retention period may vary from 4 weeks to 6 months depending on the main purpose of treatment, retention was performed for 8 weeks in the majority of cases[1-6]. For this reason, 8 weeks retention was done in present cases.

A circumferential supracrestal fibrotomy is also recommended in several reports to prevent the coronal displacement of the gingival margin that occurs during extrusion and to avoid the relapse of treatment[2,6]. In this report, alteration of the gingival margin was occurred only in the first case due to the alteration of treatment method. Although fiberotomy could have been performed each visit, surgical recontouring was performed because it is more reliable for both the clinician and the patient.

From the endodontic perspective, proper pulp treatments are needed in complicated crown-root fracture cases and vary depending on the root development stage. If the root formation is complete, a root canal

treatment is indicated. Otherwise, pulp capping or pulpotomy is advised for the completion of root formation[7]. In the first case, conventional root canal treatment was performed because the root formation was almost completed, the diameter of pulp exposure was large and several hours had already passed after the trauma. In the second case, the root formation was incomplete and the prognosis of the tooth was presumed to be poor due to the patient did not visit the clinic immediately after the trauma and the diameter of pulp exposure was large. Therefore, apexification was planned. Although, conventional therapy of apexification includes the use of a dressing with a calcium hydroxide paste, formation of a hard tissue apical barrier can be prolonged[1,4,7,8]. At present, MTA appears to be a promising candidate as an alternative to calcium hydroxide. MTA apexification can be completed in one or two visits[7,8]. Due to its biocompatibility, good prognosis and short treatment time, MTA apexification was performed.

There are several options for restoring the fractured tooth; the selection depends on various factors such as extent of fracture, patient age, dental eruption, presence of fractured tooth fragment, amount of remaining tooth structure, occlusion and esthetics[1,3]. In the past, fractured teeth were restored using acrylic resin or porcelain fused to metal (PFM) restorations. These restorations did not satisfy the esthetic requirements. Recent advancements in materials and bonding techniques make it possible to combine prosthodontic procedures using ceramic restorations with a minimally invasive approach using new composite materials to ensure excellent esthetics[2]. In the present cases, the placement of an endodontic fiber-optic posts and ceramic crown restorations was indicated because the fractures involved more than two-thirds of the crown[2,9]. In the first case, all ceramic crown was planned due to the patient was at permanent dentition period and showed favorable occlusion. On the other hand, the patient in the second case was at mixed dentition period and showed deep anterior over bite. However, the patient didn't want the overall orthodontic treatment, and wanted to proceed the treatment as soon as possible. For these reasons, selection of the restoration material was difficult. The prosthodontist finally planned PFZ crown for the patient due to the lower possibility of fracture comparing to the all ceramic crown. In addition, if the tooth discoloration occurs due to MTA, zirconia may be helpful to block out the discoloration showing through. The use of a fiber-optic post gives good esthetic results, increases retention, and distributes the stresses along the root[7]. In addition, CAD/CAM system was used for ceramic restorations. Tooth preparation for CAD/CAM system, the surface of the prepared tooth should be soft due to get an accurate image through oral scanner. Recent analysis of clinical and laboratory data demonstrated that CAD/CAM restorations are a reliable and esthetic alternative that may provide a superior outcome relative to conventional fabrication systems[10,11]. The survival probabilities of CAD/CAM restorations were reported to be approximately 97% for 5 years and 90% for 10 years[11]. The clinician should consider that the diameter of the root would be reduced with progression of the extrusion, which involves expansion of interproximal gingival embrasures. The contour shape of the crown must not be exaggerated to compensate for this reduction in diameter because it could adversely affect the marginal periodontium[5,6]. This problem did not occur in the cases presented, probably due to the shape of the tooth and traction movement of only 2.0 to 4.0 mm.

As mentioned above, treatment of complicated crown-root fracture in young patient is complex. Various factors should be considered in establishing the treatment plan and many variations of treatment method may exist. In present cases, rapid orthodontic extrusion was planned to prevent the alteration of the gingival level. However, rapid extrusion could not be performed in one patient inevitably, slow extrusion was performed. Though gingival alteration appeared by not performing circumferential supracrestal fibrotomy during slow extrusion, esthetic gingival line could be accomplished by gingivectomy. Finally, favorable results were produced by selecting proper type of ceramic crown considering the patient age, dental eruption, amount of remaining tooth structure, occlusion and esthetics.

Ⅳ. Summary

The present cases demonstrate multidisciplinary management of crown-root fracture. After endodontic treatment and orthodontic extrusion, satisfactory esthetics were achieved by applying ceramic crowns with fiber-optic posts. In addition, the development of the materials and CAD/CAM systems facilitated use of CAD/CAM restorations as a dependable, esthetic restorative option for patients.

Though the patients might need to undergo replacement of the prostheses after completion of growth, the

treatment is meaningful in terms of conservation of the tooth, the alveolar bone, and rehabilitation of both the function and esthetics of the tooth.

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국문초록

복합 치관-치근 파절의 교정적 정출술을 이용한 심미적 수복

김민지 · 김진영 · 김수현 · 임수민

선치과병원 소아치과

영구 전치의 복합 치관-치근 파절은 심미적, 기능적 문제 뿐 아니라 심리적 문제도 발생시킨다. 그러므로 파절에 대한 치료는 매우 중요하며, 여러 분야에 걸친 종합적 치료가 요구된다.

본 증례는 두 환자에서의 외상으로 인한 상악 전치의 복합 치관-치근 파절에 대한 임상적 치료 과정을 서술하였다. 근관치료와 근첨형성술이 각 환자에게 시행되었으며, 파절선을 치은 상방으로 노출시키고 생물학적 폭경을 재확립하기 위해 교정적 정출을 시행하였다. 이후 유지기간을 두었고, 그 기간 동안 치아에 임시수복을 시행하였다. 최종적으로 CAD/CAM을 이용한 세라믹 크라운 수복을 시행하였다.

이후 정기 검진 때에도 해당 치아들은 만족스러운 기능적, 심미적 결과를 보였으며, 두 환자 모두에서 재발은 나타나지 않았다. 치주조직 또한 건강한 상태를 보였다.

주요어: 복합 치관-치근 파절, 상악 전치, 교정적 정출, 심미 수복