

Surgical extrusion: state of the art and literature review

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KEYWORDS Surgical extrusion, intra-alveolar transplantation, intra-alveolar repositioning, surgical extrusion and procedure, case report

ABSTRACT

Aim Surgical extrusion, also known as intra-alveolar transplantation or intra-alveolar repositioning, is instead defined as the procedure in which the remaining tooth structure is repositioned in a more coronal/supragingival position in the same socket where the element was originally located. Therefore, the present systematic review aimed to describe the indications and results obtained by surgical extrusion technique, analyzing the recent literature.

Materials and Methods To perform this review articles were electronically searched in PubMed/MEDLINE, the COCHRANE library and Google Scholar by two independent reviewers, and those that met the eligibility criteria were included.

Results 26 articles were included in the qualitative analysis, 14 case reports and 12 case series. The survival rate reported was 100% with documented follow-up from one year to 10 years.

Discussion Surgical extrusion technique is a valid therapeutic alternative in cases of fractured teeth and intruders due to trauma or in cases of teeth with coronal-root fracture, surgical extrusion was an effective and predictable technique.

Conclusions This surgical technique combined, with modern adhesive techniques and the latest generation materials, allows for highly predictable results from the functional and aesthetic aspects, especially in the anterior region.

traction and replacement with dental implants is a common treatment choice. However, the survival rate for implants is lower than for teeth, even if severely damaged but properly treated (1).

In order to re-establish a physiological supracrestal tissue attachment of damaged teeth and to organize an efficient ferrule effect, three therapeutic options can be considered: crown lengthening, orthodontic extrusion and surgical extrusion. Crown lengthening is considered an invasive technique that causes the removal of part of the bone support, but this surgery can alter the morphology of the soft and hard tissues of the involved and neighboring teeth, with possible undesirable aesthetic and phonetic outcomes (2,3).

Regarding orthodontic extrusion, this is a technique with predictable results but however, this approach is not without limitations, including patient acceptance, increased costs, and prolonged treatment duration (4,5).

Surgical extrusion, also known as intra-alveolar transplantation or intra-alveolar repositioning, is instead defined as the procedure in which the remaining tooth structure is repositioned in a more coronal/supragingival position in the same socket where the element was originally located. The success of this procedure is based on the ability to heal the alveolus that occurs following the repositioning of the element, leaving sound tooth structure exposed to improve tooth restorability and providing space for the reestablishment of the biologic width (6). This technique was described for the first time by Tegsjö in 1978 (7), in relation to cases of fractures occurring in the aesthetic area, in young patients. The clinical procedure for surgical extrusion has undergone several changes over the last few years and there are no protocols that can guide the clinician in choosing the most appropriate treatment. Therefore, the goal of

INTRODUCTION

The need to rehabilitate severely compromised teeth is frequent in daily clinical practice. When a significant amount of dental tissue is lost due to extensive dental caries, fractures, or other causes, treatments are often required to restore any violated biological width, in order to save the dental element. Tooth ex-

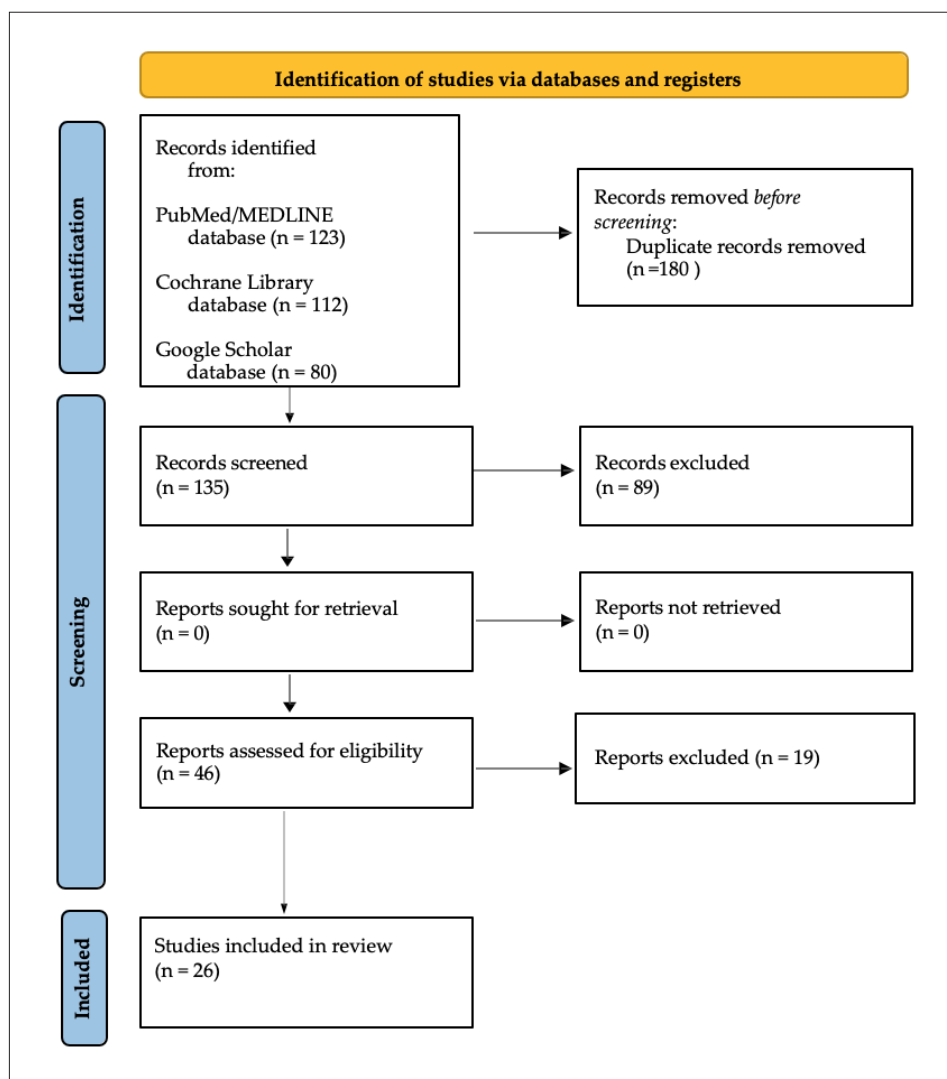


FIG. 1
Study selection flowchart

this review is to describe the indications and results obtained by surgical extrusion technique, analyzing the recent literature.

MATERIALS AND METHODS

Search strategy and study selection:

A literature search was independently conducted by two reviewers (G.S, F.G.), across PubMed/MEDLINE, Google Scholar and the COCHRANE library databases and gray literature, using the following keywords combined by Boolean operators: surgical extrusion OR intra-alveolar transplantation OR intra-alveolar repositioning OR surgical extrusion AND procedure OR Case-Report. Citations obtained through literature search were recorded, duplicates were eliminated using EndNote (Clarivate, Philadelphia, USA) titles and abstracts were independently screened by three reviewers (G.S., A.A. and A.V.). Available full-texts, compliant with inclusion and exclusion criteria were also independently reviewed for potentially eligible

studies. Any disagreement between the reviewers was solved by discussion and consensus.

Inclusion criteria:

Source: studies published in English language from January 1996 to 1 July 2022

Study design: case reports, case series, analytical observational studies, trials.

Study population: Subjects undergone surgical extraction (SE) of permanent teeth with no gender restrictions.

Study intervention: SE of permanent teeth.

Study outcomes: SE reported clinical and/or patient-related outcomes.

Exclusion criteria:

Source: studies published before 1996.

Study intervention: indication to treatment not specified.

Study outcomes: SE clinical and/or patient-related outcomes not available.

Search and study selection was conducted on grey

| AUTHOR | AGE | SEX | TOOTH | CAUSE | TIME OF SURGICAL EXTRUSION | TOT mm EXTRUSION | | TIME OF SPLINT | OUTCOME | FOLLOW-UP |
|-----------------------------------|-----|--------|---------------------|--|----------------------------|------------------|--------------|----------------|---------|----------------------|
| Girra 2021 (8) | 24 | male | 1.2 | complex Coronal fracture | 1 week | 3 mm | yes | 15 days | success | 2 years |
| Lee 2015 (9) | 60 | male | 1.1/1.2/1.3/2.1/2.2 | complex Coronal fracture | 6 weeks | 3mm | yes | no splint | success | 18 months |
| Ming-Pang Chung 2010 (10) | 30 | male | 1.2 | complex coronal/radicolar fracture | 2 weeks | 3mm | yes | no splint | success | 1 year |
| Kirzioglu 2007 (11) | 9 | male | 2.1/1,1 | 2.1 uncomplex crown fracture/ 1.1 complex coronal fracture | 15 days (2 weeks) | 5mm | yes | 21 days | success | 3 years |
| Caliskan 1998 (12) | 10 | male | 2.1 | fracture and intruded trauma | 7 days | 7 mm | yes | no splint | success | 18 months |
| Caliskan 1998 (caso 2) | 8 | male | 1.1/2.1 | uncomplicated crown fractures | 3 weeks | / | yes | no splint | success | 2 years |
| Caliskan 1999 (13) | 10 | male | 1.1 | uncomplicated crown fracture | 2 years | 4 mm | yes | no splint | success | 27 months |
| Chang-Sung Kim 2004 (14) (case 1) | 42 | female | 2.2 | horizontal fracture | / | 3mm | no immediate | no splint | success | 17 months |
| (case 2) | 40 | male | 3.1 | horizontal fracture | / | 4mm | no immediate | no splint | success | 18 months |
| (case 3) | 45 | male | 1.3 | fracture and secondary dental caries | / | 4 mm | no immediate | | success | 13 months |
| Dias 2009 (15) | 10 | male | 1.1 | complete intrusion | 7 days | / | no immediate | no splint | success | 3 years and 2 months |
| Gungor HC 2006 (16) | 10 | male | 2.2 | intrusion/ uncomplicated fracture | 1 h | 7 mm | yes | 3 weeks | success | 28 months |
| Caliskan 2008 (17) | 12 | male | 1.1 | partial intrusion | / | / | no immediate | no splint | success | 2 years |
| Nelson-Filho 2006 (18) | 10 | male | 2.1 | intrusion/ uncomplicated fracture | 15 days (2 weeks) | / | no immediate | 15 days | success | 10 years |
| Senem Yigit - Ozer 2014 (19) | 19 | male | 4.3 | crown-root fracture | 3 days | 4 mm | yes | 2 weeks | success | 1 year |
| Mazumdar et al. (2009) (20) | 42 | male | 1.1/2.1 | intrusion/ uncomplicated fracture | 2 h | 6 mm | no immediate | 6 weeks | success | 2 years |
| Patil 2014 (21) | 17 | male | 2.1 | intrusion/ uncomplicated fracture | 2 days | 7 mm | yes | 3 weeks | success | 1 year |

TABLE 1 Case reports

literature as already described. Authors were not contacted for missing information or full-text unavailability and, in case of disagreement, the evaluation of the majority was considered (two reviewers out of three).

Data extraction and synthesis

A ten-question data extraction form was currently employed, by two independent reviewers (G.S., F.G.), to record for each of the included study: study design; participants' age and gender; treated teeth; SE indications, healing time, follow-up and reported outcomes, evaluated as success and failure; success refers to the permanence or survival of the treated tooth for a follow-up period established by each author of the reported cases. The range regarding the

follow-up relative to the treated teeth varied from a minimum of 3 months to a maximum of 10 years. A statistical chi-square analysis, evaluating SE success rate was currently employed.

Quality Assessment and Data Synthesis

Included studies were assessed for quality through the ROBINS-I (Risk Of Bias In Non-randomized Studies of Interventions) tool, evaluating the risk of bias of non-randomized clinical trials.

RESULTS

From an initial search, 315 articles relating to the keywords entered were selected. PubMed/MEDLINE

| AUTHOR | MATERIALS | TREATMENT | OUTCOME |
|------------------------------|---|--|--|
| Tegsjo et al. (1978) (7) | Twelve patients with root fractures. | Intra-alveolar transplantation with apical bone graft. Stabilization with interdental sutures. | Normal mobility was observed within 4 weeks of the procedure. No signs of ankylosis or root resorption or adverse effects on adjacent teeth were observed after 12 months of follow-up |
| Kahnberg et al. (1982) (22) | Fifteen patients with 15 complicated crown-root fracture | Intra-alveolar root remnant transplantation of the right upper second premolar with autologous bone graft to stabilize the tooth. | Mobility decreased considerably after 3 weeks. Radiographic control showed normal periodontal space; minor resorption was observed in 10 cases. In two cases periodontal problems were observed after 2 years of follow-up. |
| Kahnberg (1985) (23) | Twenty-three crown-root-fractured teeth in 23 individuals. | Surgical extrusion of the 23 teeth. Interdental sutures for stabilization | A normal periodontal contour was observed at the 3-month follow-up. At 12 months, slight mobility was found in 3 cases with normal probing depth; radiographic examination revealed resolution of the radiolucency. |
| Tegsjo et al. (1987) (24) | Fifty-six teeth with complicated crown-root fractures with patient's ages ranging from 9 to 33. | Intra-alveolar transplantation of 56 teeth. of these 56, 8 were extracted for prosthetic reasons or other trauma | All teeth showed healing without ankylosis. Resorption within the apical area was observed in 12% of cases. |
| Kahnberg 1988 (25) | Cervical root fracture in 58 single roots in 53 patients. | Group I, made up of seventeen patients, underwent surgical extrusion with autologous bone transplantation. Group II, made up of the rest of the sample, underwent surgical extrusion, without performing autologous bone transplantation and stabilization was performed with interproximal sutures. | Apical resorption was observed in 17 roots, but was not progressive in all cases. Root resorption was more evident in Group I. |
| Warfvinge et al. (1989) (26) | Twenty-six crown-root fractured teeth | All teeth were treated with the intraalveolar transplantation technique. Group I underwent endodontic treatment before transplant. In Group II, endodontic treatment was performed 3-4 weeks after transplantation | Bacteriological testing showed that teeth in Group II required fewer treatments to provide a noninfected canal than teeth in Group I. Only in 5 of 21 teeth treated. periapical destruction was observed over a period of 2 years; 3 of which belonged to Group I. |

TABLE 2 Case series

(123 articles), Google Scholar (80 articles) and the COCHRANE library (112 articles). Of these, 180 were excluded because duplicates or the full text were not available. Of the remaining 135 articles, 46 were considered appropriate, but 19 were excluded because the full-text review did not reveal clinical cases treated with the technique IR. Finally, 26 articles were included in the qualitative analysis (Fig. 1).

14 case reports were included as compatible with the relevant inclusion criteria, for a total of 17 clinical cases covered with the surgical extrusion technique. A statistical analysis of the results was subsequently carried out. The sample consisted of 17 subjects, of which 16 males (94.1%) and 1 female (5.9%).

Age ranged from 8 to 60 years, with a mean age of 23.4 years. The total number of teeth on which the surgical extrusion technique has been practiced is 24. Of these, the most treated were the right upper cen-

tral incisors (29.1%), the left upper central incisors (29.1%). The left maxillary lateral incisor (12.5%) and the right lateral incisors (12.5%). In these percentages, the right maxillary canines (8.3%), the left mandibular canine (4.1%) and the right mandibular canine (4.1%) were processed.

The cause that led to the surgical extrusion, in 22 teeth, is represented by the presence of a complicated or uncomplicated coronal-radicular fracture (91.6%); 6 teeth were surgically extruded for the treatment of a trauma that led to the intrusion of the element (25%). The time elapsed from the trauma and the treatment ranges from 1 hour to 6 weeks and the millimeters of extrusion performed range from 3 to 7 with an average of 4.3 mm. Endodontic treatment was performed on 16 elements (66.6%) in the same session as the surgical extrusion. The remaining 8 teeth (33.4%) underwent endodontic treatment at a later time. After

| AUTHOR | MATERIALS | TREATMENT | OUTCOME |
|----------------------------------|---|--|---|
| Kahnberg et al. (1996) (27) | Twenty-one root-fractured teeth in 19 patients | Intra-alveolar transplantation of the cervical root fractures | With the exception of one of the 21 intraalveolar transplanted roots, all functional with different types of coronal restorations without complications. |
| Caliskan et al. (1999) (13) | Twenty patients with crown-root fracture with patient's age ranging from 10 to 45 years. | Surgical extrusion and then endodontic treatment were performed in 7 teeth. In 13 teeth, endodontic treatment was performed before extrusion. | Radiographic and clinical evaluation over the 6- to 36-month follow-up period showed no progressive resorption or bone loss, except for 1 tooth, which showed marginal alveolar bone loss |
| Ebeseleseder et al. (2000) (28) | Fifty-eight traumatically intruded teeth. | 48 teeth were surgically repositioned and stabilization was performed with wire and a composite splint. | Necrotic pulps were found in 61% of all immature teeth and 88% of all mature teeth. External root resorption was observed in 68% of immature and 73% of mature teeth. Three teeth were lost out of 48 extruded teeth. |
| Tsilingaridis et al. (2011) (29) | Sixty intruded permanent teeth in 48 patients (32 boys and 16 girls) aged 6-16 years | Spontaneous eruption (seventeen teeth), 12 teeth treated with the orthodontic extrusion technique and 31 with surgical repositioning | The authors reported that no definitive conclusions could be drawn. |
| Akbar Khayat 2006 (30) | 21 developed single roots (1 upper and 3 lower) surgically extruded in 17 patients (15 male and 2 female mean age 26 years, ranging 10-40) | Surgical extrusion followed by endodontic treatment was performed. In case of a palatally inclined fracture, the roots were rotated and placed in an appropriate position. | Radiographic examination revealed PDL healing at 12 months follow-up in 20 teeth (95.2%). 4 teeth (19%) showed crestal bone resorption between 1 and 3 mm |
| Hien Tin Pham 2018 (31) | 18 patients (6 males and 12 females), non-smoking patients aged at least 18 years old with a single crown-root fractured mature anterior tooth. | Following pre-surgery procedures and examination, minimally traumatic controlled surgical extrusion was carried out using a periosteal elevator. Patients were examined at four follow-up appointments after 1 week, 1 month, 3 months, and 6 months to record the following experimental variables: periodontal parameters including the gingival index (GI); pocket depth (PD); bleeding on probing (BOP); mobility; marginal gingiva position; alveolar ridge resorption; periapical osteogenesis; tooth resorption; and ankylosis. | The position of the marginal gingiva and the resorption of the alveolar ridge were not significantly different between preoperatively and 1, 3 and 6 months postoperatively. No cases of root resorption or ankylosis were observed 6 months after surgery. |

TABLE 3 Case series

treatment, 8-unit (33.3%) was given a splint which was removed 2 to 6 weeks later. Splinting was not applied in 66.4% of cases. The survival rate reported was 100% with documented follow-up from one year to 10 years. Twelve case series were included in which 388 teeth were treated with the surgical extrusion technique. (Tab. 3).

DISCUSSION

From the analysis of the data reported in the case reports and the case series, it emerged that the surgical extrusion technique is a valid therapeutic alternative in cases of fractured teeth and intruders due to trauma (11,12,13,15,16,17,26,32,33,34,35,36). Even in cases of elements with coronal-root fracture, surgical extrusion was an effective and

predictable technique. The absence of complications and good tissue healing was also observed, with good maintenance of marginal bone height and healing of periapical radiolucencies (13, 22,23,24,25,26,27).

The SE technique, if applied with particular attention to selected cases, is a simple, fast and successful procedure with a survival rate compatible with dental implants.

The success observed from the analysis of the following review is close to 95%-100% with follow-up times ranging from 1 to 10 years. Regarding the definition of success, the following clinical and radiographic parameters were examined: the periodontium healthy, with no root resorption, presence of ankylosis, loss of marginal bone and tooth mobility (37). To achieve long-term success, it is considered essential for many authors that the extrusion be as little traumatic as possible so as not to damage the root cementoblastic layer (38).

Regarding the steps of this procedure, after reviewing

the literature, it can be summarized in the following steps: anesthesia, fibrotomy, luxation, extrusion, stabilization, finalization. On anesthesia, many authors advise against the use of the intraligamentous technique, as it could cause ischemia. Subsequently, the dental structure affected by caries is removed (if this is present). Then the next step is fibrotomy, for which many authors recommend a thin blade to penetrate deeper into the periodontal ligament. This procedure aims to facilitate the subsequent luxation that must be performed with delicate maneuvers, paying particular attention on placement and by using elevators and forceps (39).

Several authors indicate the possibility of damaging the cells of the root surface as a criticality of this phase, with a subsequent loss of bone at the margin. For this reason, some authors recommend placing the forceps at the level of the amelocemental junction. According to other authors, to facilitate this phase it is advisable to make small marginal incisions to improve the grip of the forceps (39,40). The extrusion phase, on the other hand, depends on the depth of the lesion, on the amount of residual healthy structure, and on the type of reconstruction planned to rehabilitate the element. According to a study by Caliskan et al. (13), where 20 cases were analyzed, they report that the average extrusion was 4.25 mm. While Elkhadem et al. (37) report from a review of the literature that the mean was 4.5 mm. In cases where a restoration with a post and a complete crown is planned, the distance between the prosthetic margin and the marginal bone should be at least 3 mm, consequently another 1.5 mm is necessary to have an adequate ferrule effect, which involves an extrusion of at least 4.5 mm. In cases where the residual coronal structure would allow the possibility of performing a partial adhesive restoration, such as an onlay or an overlay, the amount of extrusion required must be the minimum that will allow the use of the rubber dam and perform the adhesive procedures correctly. Andersson et al., (41) report that root canal treatment should be performed within 2 weeks after surgical procedures to prevent root resorption (42, 43). According to some authors, in cases in which root resorption was found this was of a non-progressive nature, and was associated with cases in which periapical bone graft surgery was performed, or in teeth where endodontic treatment preceded surgical extrusion (44).

As regards stabilization, for some authors only the position of a mesial and distal suture to the treated element is indicated. This would allow a functional stimulation, which would guarantee a correct healing of the periodontal ligament fibers, in order to reduce the risk of ankylosis. Also according to Caliskan et al. (17) it would be sufficient to splint the tooth for 1 week, while keeping it for more than 3 weeks would

significantly increase the risk of ankylosis. In cases treated with splinting, mobility decreased over a period of 3-4 weeks, Kahnberg et al. (23) observed mobility in 2 cases after 12 months of follow-up. Other authors suggest using composite to splint the tooth for a period of no more than 2 weeks, with the aim of avoiding root displacement, especially in cases where there is a significant discrepancy between the diameter of the root and the size of the alveolus. According to Fouad, to promote periodontal healing, the splint must be passive, flexible and allow good oral hygiene (45). To meet these requirements, thin threads no larger than 0.3 – 0.4 mm are usually bonded to the buccal surface of the tooth (46). After approximately 45 days there is a reduction in mobility due to the healing of the periodontal ligament. Kim et al. (14) observed radiographically that the apposition of new periapical bone 2 months after the SE. For other authors, approximately 60 days after the treatment, it is possible to finalize the procedure with direct or indirect restorations. Restoration of the periodontal space was observed in most cases at the 3-month of follow-up. Kahnberg (27) performed a 10-year follow-up study in which he reported only 1 extraction after 8 years of therapy, on 21 treated teeth (19 patients), due to cervical resorption. In the other cases, a modest apical resorption was observed, of about 0.5 mm, which in all cases did not compromise the function of the treated teeth. Periapical healing was observed by all reported authors, although one study showed a slight loss of marginal bone height in one of the 20 treated teeth (13). Nelson-Filho (18) reported a case with a 10-year follow-up in which the absence of clinical and radiographic signs of ankylosis was reported, according to Becciani et al (41) that reported successes at 20 years of follow-up.

Among the main indications of SE are coronal-root fractures, subgingival caries, cervical root resorption, root perforations in cases where other therapies have failed and incongruous prosthetic preparations that violate biological width (47).

Several authors include among the contraindications of this technique, the presence of an ankylosed root, the presence of multiple roots, systemic conditions that contraindicate surgery and finally the long-term therapy with bisphosphonates (48, 49, 50, 51). Many Authors reported the importance of controlling the risk factors for the success of the therapy (52, 53, 54). The relative contraindications include the presence of a crown-root ratio less or equal than 1:1.

CONCLUSIONS

Surgical extrusion seems to be a valid alternative in cases where damage to the dental structure makes the reconstructive procedures of the dental element impossible. This surgical technique combined with

modern adhesive techniques and the latest generation materials allows for highly predictable results from the functional and aesthetic aspects, especially in the anterior region.

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