Evaluation of Long-Term Efficacy of Forced Erupted Teeth for Restorative Purposes: A Clinical Retrospective Study

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This retrospective study evaluated the long-term stability of teeth that were orthodontically treated with forced eruption for restorative purposes. A total of 25 participants with a total of 36 orthodontically extruded teeth were included in the study. The measured clinical parameters included (1) pre- and posttreatment radiographs, (2) activation time, (3) retention time, (4) total treatment time, (5) additional treatment required to restore the teeth, and (6) pre- and postsurgical complications. The results show a 96.0% survival rate for force-erupted teeth, with a 4.0% failure rate due to nonrestorable caries. When more than 1.0 mm of extrusion was completed, there was a statistically significantly higher chance that the tooth required additional surgeries (P < .05). Complications during treatment were higher in clinicians without orthodontic training (43.0%) vs clinicians with orthodontic training (10.0%). Forced eruption for prosthetic treatment and implant site development is a viable treatment option and is successful in the long-term. Int J Periodontics Restorative Dent 2022;42:809–815. doi: 10.11607/prd.5928
support. Orthodontic extrusion is considered a conservative procedure for multiple restorative purposes, as it does not compromise the alveolar support of the tooth or periodontal tissues. Extrusion is a popular treatment modality to avoid surgical procedures (eg, functional crown lengthening or dental extractions), and it does not require complicated orthodontic movements. However, there is limited research evaluating the prognosis and longevity of a tooth after forced eruption is completed. Therefore, the present study evaluated the long-term (>1 year) stability of teeth that were orthodontically treated with forced eruption for restorative purposes by evaluating clinical factors that may influence treatment outcomes.

Materials and Methods

This study is an investigator-initiated retrospective study. Data collection and analysis were performed by the same examiner (M.Q.). The clinical data and medical history of patients who underwent forced tooth eruption at the Pennsylvania Dental Medicine clinics were obtained from the years 2012 to 2020 using an oral health database (axiUm, Exan Software, Henry Schein). Institutional review board approval was obtained from the University of Pennsylvania prior to collecting any retrospective data from patient records.

All patient information was collected without any identifiers, codes, links, or other means of associating the data to the subject’s identity. Demographic variables extracted included age, gender, race, smoking history (past and present), and health status as classified by the American Society of Anesthesiologists (ASA).

Inclusion criteria consisted of patients of all ages who were systemically healthy (ASA I or II) with records that included pre- and post-treatment radiographs. Patients were excluded from the study if they had active periodontal disease or acute endodontic infection.

From the electronic medical records, the following variables were extracted: number and locations of teeth involved, technique of forced eruption, duration of forced eruption, activation time, retention period, intrusion of adjacent teeth (if present), presence of mucogingival defects, fiberotomy, additional requirement of hard or soft tissue surgical procedures before or after the forced eruption, any complications that occurred during or after forced eruption movement, and radiographic data (pre- and post-extrusion). Radiographic measurements were completed before and after treatment to measure the root length and the distance from the crown margin to the alveolar bone crest (Fig 1).

Statistical Analysis

The initial data evaluation comprised normality verification (Prism software, version 9), and the appropriate parametric or nonparametric statistical methods and post-hoc tests were selected. Percentages, distributions, means, and standard deviations were presented as descriptive data for all clinical variables. Paired t test ($P < .05$) was used to assess the distance from crown margin to bone crest and root length before and after forced eruption. Mann-Whitney U test ($P < .05$) was used to evaluate the correlation between the need for additional surgical treatment and the extrusion distance.

Results

A total of 25 patients with 36 orthodontically extruded teeth were included in the study: 10 men (40.0%) and 15 women (60.0%). Regarding their health history, 11
patients (44.0%) were classified as ASA I and 14 patients (56.0%) were classified as ASA II, with 24 nonsmokers (96.0%) and 1 (4.0%) smoker. In the maxilla, 34 teeth were extruded: 26 anterior teeth (72.2%) and 8 posterior teeth (22.2%). In the mandible, 2 teeth were extruded (5.6%), and were both posterior teeth. The examined cases were followed up for 1 to 7 years (mean: 3.3 years).

The present study evaluated different scenarios in which orthodontic extrusion was included in the treatment plan—through either fixed appliances (n = 33) or removable clear aligners (n = 3)—for prosthetic treatment, implant site development, and esthetic treatment. Prosthetic treatment included alternatives to surgical crown lengthening or manipulating tissues for increased papillary contour, or to improve gingival margins around future restorations. Within the study, 26 teeth were extruded for prosthetic purposes: 19 teeth were extruded due to inadequate crown length, 4 teeth were extruded for gingival augmentation to vertically augment the papillary height, and 3 were extruded to improve the facial gingival margin for future restorative purposes. Ten teeth were planned for extraction and were extruded to coronally position the alveolar crest to increase stability for a one-stage implant placement at the time of extraction.

The overall treatment period ranged from 3 to 16 months (mean: 7.05 months), and the overall treatment time for prosthetic purposes ranged from 1.2 to 14 months (mean: 6.12 months). The overall period for implant site development ranged between 4 to 16 months (mean: 9.2 months). The mean activation time for adequate extrusion was 2.86 weeks (range: 1 to 4 weeks). Following the activation time, retention periods differed for teeth extruded for prosthetic purpose vs implant site development: Teeth that were extruded for prosthetic purposes had a retention period of 4 to 6 weeks (mean: 5.11 weeks), while teeth that were extruded for implant site development were treated orthodontically for 12 to 14 weeks (mean: 12.3 weeks) prior to tooth extraction.

Radiographic measurements were made at baseline (before extrusion) and postextrusion to evaluate the overall crown length (measured as the distance from the crown margin to the alveolar bone crest) and the root length (measured from the root apex to the alveolar crest). There was a statistically significant increase (P < .05) in crown length between these time points (Figs 2 and 3). When comparing the change in crown length and root length between anterior and posterior teeth, there was a statistically significant increase in crown length in both anterior (P < .01) and posterior (P < .001) teeth. However, there was no significant change in root length, irrespective of tooth location (Figs 4 and 5).

In addition to evaluating the changes in clinical measurements of the teeth, the effectiveness of the forced eruption procedure was evaluated. It was noted that when the tooth was extruded more than 1.0 mm, there was a statistically significantly higher chance (P < .05) that the tooth required additional surgeries. When tallied, the additional treatments that each tooth required were either fiberotomy alone (n = 3), gingivectomy alone...
(n = 2), combined fiberotomy and gingivectomy (n = 1), or crown lengthening (n = 5).

In sites where the tooth was extruded prior to extraction for implant site development, 9 out of the 10 teeth were extracted with immediate one-stage implant placement, while the remaining tooth was extracted with subsequent ridge augmentation for delayed implant placement.

Survival rates and posttreatment complications of the orthodontically extruded teeth were also examined. Of the 26 teeth extruded for prosthetic purposes, 25 survived (96.0%) and 1 failed (4.0%) over an average follow-up period of 3 years (range: 1 to 7 years) after forced eruption, and the teeth were still in function.

Figures 6 to 8 show example clinical cases of patients who underwent forced eruption.

**Discussion**

Forced eruption, also known as orthodontic extrusion, is most commonly performed in the maxilla, as it is often driven by the esthetic demand attributed to the maxillary smile line. Forced eruption can be achieved using either a fixed or removable appliance. In cases where removable appliances were used, patient compliance was a factor that hindered the fixed treatment period. Both appliances required recall for additional activation, with appointments ranging between 1 and 4 weeks after extrusion (mean: 3 weeks). Preadjusted edgewise appliances with rectangular wires should be used with small activation increments to three-dimensionally control tooth movement. This minimizes the risk of buccal dehiscence due to loss of torque. Generally, the slower activation period with a rectangular wire has been proven to have the most predictable outcome. Throughout the movement period, periodic occlusal adjustments are required to create space for the teeth to erupt without undergoing traumatic occlusion.

Generally, a shorter treatment period is required for sites undergoing orthodontic extrusion for prosthetic purposes compared to sites developed for implant placement. For prosthetic cases using extrusion to increase crown length, a fiberotomy is completed prior to extrusion to aid in orthodontic movement. A fiberotomy, as discussed by Pontoriero et al, involves severing the connective tissue attachments around the tooth on a regular basis. In the present study, it was seen that cases that received a fiberotomy 1.5 to 3 weeks after orthodontic initiation did not need any additional surgeries after the forced eruption was completed. Regarding the relapse, it was noted that it was not an issue for the cases included in this study. The teeth were prepped and given a provisional restoration after the retention period, which could help reduce the incidence of relapse. When the fiberotomy was completed in the middle of orthodontic extrusion, the case required an additional gingivectomy at the completion of
the procedure for an esthetic outcome.

In agreement with the present findings, Cordeiro da Silva et al used CBCT scans to demonstrate that orthodontic extrusion has a minimal effect on the root length and the buccal and palatal alveolar bone levels in both the extruded tooth and the adjacent teeth, indicating that this treatment protocol has a good long-term prognosis. The most common adjunctive surgical procedure in the present study was crown lengthening. Teeth that were planned for extraction at the end of orthodontic extrusion were due to caries and nonrestorability, not

Fig 6 (a) Pretreatment clinical view of a nonrestorable maxillary central incisor. Note the gingival asymmetry between the two incisors. (b) Clinical view 8 months after orthodontic extrusion. The dotted line marks the crown margin of the nonrestorable tooth in relation to the adjacent tooth. (c) Clinical view after implant placement and crown delivery. The dotted line marks the crown margins, which are now symmetrical. (d) Radiographic views before and (e) after extrusion and implant placement. The dotted lines mark the crown margin of the nonrestorable tooth.

Fig 7 (a) Intraoperative and (b) postoperative views of an example buccal dehiscence complication that formed as a result of using a round wire during forced eruption, which lead to the loss of torque.
periodontal complications. In the present findings, the total survival rate of the teeth that underwent forced eruption was 96.0%, which indicates that orthodontic extrusion is a viable, successful treatment option for prosthetic treatment, implant site development, and esthetic treatment goals. In a retrospective study by Choi and Lee,12 21 cases exhibited an overall success rate of 85.7% with a 100% survival rate; however, it is important to highlight that the study was only done on single, tapered-root maxillary premolars. Still, the long-term prognoses of the teeth included in Choi and Lee’s study12 were deemed overall favorable, with an average follow-up period of 3 years (range: 1 to 7 years) after forced eruption, and the teeth were still in function.

In the present study, the frequency of complications significantly increased for clinicians who were not trained orthodontically. One of the complications resulted from using a round wire, which caused a loss of torque of the teeth, leading to a buccal dehiscence. This complication can be managed by providing adequate torque through a bend in the wire, by torqueing the auxiliary, or via reshaping of the root surface. Choi and Lee12 also highlighted tooth mobility as another possible complication from extrusion. Clinicians should consider residual root length and shape to maintain a favorable crown-to-root ratio.12

This retrospective study provides insight into the longevity of teeth extruded for prosthetic purposes and implant-site development. However, there are limitations that must be considered: Conclusions cannot be extrapolated to the general population due to the sample size, with incomplete data sets from each chart; additionally, the radiographs used to measure the crown and root lengths were not standardized. Future prospective studies should be completed to (1) investigate the maximum time needed between fiberotomies to mitigate the need for additional surgeries and (2) evaluate keratinized tissue deficiency and the effect of extrusion.

Conclusions

Forced eruption for prosthetic treatment and implant-site development is successful in the long term (> 1 year). Orthodontic training helped improve clinical outcomes and decrease complications. However, additional surgeries may be required for forced eruption cases, the most common of which is crown lengthening.

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