Systematic review of forced eruption from an orthodontic perspective

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Single tooth orthodontic movements in multidisciplinary treatment are common procedures, eventually leading to a more successful treatment with improved prognosis. Such orthodontic movements therefore are actually applied for purposes other than comprehensive treatment. An example of such forces is forced eruption, extrusion of a tooth for gaining access to its remaining tooth structure in order to provide satisfactory treatment results.

The term forced eruption has been also applied to the extrusion of impacted teeth[1,2]. Although the basic movement - extrusion - is actually the same in both, Proffit [3] has categorized forced eruption as an adjunctive orthodontic treatment according to the following criteria:

- Involving only a segment of the arch.
- Usually completed within 6 months.
- Can be carried out in the general practice.

The first published attempt for treating root fractures with forced eruption as a combined endodontic-orthodontic treatment regimen was introduced by Heithersay [4] and later by Ingber[5]. Since then, many articles have been published which favor the use of forced eruption in such treatments.

The most common application of forced eruption is for restoring severely damaged teeth, mainly using conventional orthodontic appliances. Different authors have recommended different appliances and protocols, each with its own advantage and disadvantages. Therefore, it is not surprising that most reviews on forced eruption discuss the matter from a restorative or periodontal view.

This article tries to search more recent literature for other applications of forced eruption and compare the strategies and advantages of different appliance designs from an orthodontic point of view. Techniques, appliances, safety mechanisms and retention are the main scope of this review.

Methods and material

To identify all the studies on forced eruption a literature survey was done by applying the Medline database (Entrez PubMed, www.ncbi.nim.nih.gov). The survey covered the period from January 1966 to December 2005 and used the Medical Subject Headings (MeSH) terms for forced eruption. MeSH terms for forced eruption included two headings: "orthodontic extrusion" and "crown lengthening". Search with the first heading only resulted in 3 results, and the latter dealt mainly with surgical procedures which was not the subject of this review. Therefore, Pubmed was searched using the key word "forced eruption" itself.

Results

53 out of 85 preliminary articles qualified for this review. The results dealing with forced eruption as a main issue and as adjunctive or multidisciplinary treatment were selected as inclusion criteria.

All articles including reviews, case reports, clinical studies which employed foced eruption with an appliance were selected for this study. Associated textbooks on orthodontics, periodontics, prosthetic and restorative dentistry and endodontics were used in this review.

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Common applications of forced eruption

Forced eruption in restorative dentistry:

The most common use of forced eruption is for restoration of severely damaged teeth . In order to gain access to remaining sound tooth structure and provide well defined, supra gingival restoration margins, two options exist:

First performing surgical crown lengthening procedures which requires bone removal and bone contouring. In this situation, bone removal has to be extended to adjacent teeth to allow the contours to "blend" [6]. This means that the osseous structure of neighboring teeth shall be inevitably sacrificed. The second option is by the means of forced eruption procedures. Controlled extrusion of the tooth especially in combination with a simple fibrotomy brings the tooth margins into a more desirable and accessible level [7]. With this method, the opening of interproximal spaces could also be prevented [8], resulting in more esthetic results which is also an important consideration in the anterior region 8. Many review articles and case reports favor the use of forced eruption as claim it to be a superior alternative to surgical crown lengthening procedures [6,8-18].

Periodontal benefits:

In addition to restorative benefits, periodontal advantages also exist for the use of forced eruption [19].

Periodontal intervention for eliminating pockets and infrabony defects usually requires invasive surgical procedures which results in removal of soft and hard tissue in order to provide a healthier environment where the patient could maintain hygiene more easily [20]. In contrast, forced eruption moves the tooth and changes the defect position and contour in such manner that a minimum amount of tissue reduction would be required or even unnecessary [19]. It has been shown that infrabony defects are converted into suprabony defects where prognosis and maintenance is improved [20,21]. The number of pathogens in the gingival sulcus also decreases by conversion of subgingival plaque into a supragingival type [22].

Less common and more recent applications of forced eruption

Gaining access to subgingival tooth structure:

External or internal root resorption, iatrogenic perforations are conditions which require adequate access in order to be properly handled. Forced eruption provides such opportunity to gain access to these difficult sites [23].

Trauma:

Teeth which have been intruded due to traumatic impacts in many instances need to be extruded [24]. Forced eruption is the treatment of choice for such cases [25].

Extraction:

Extraction of a tooth by gradual orthodontic extrusion has been named as "orthodontic extraction" [26]. In cases where routine extraction of a particular tooth is not feasible, forced eruption may be purposely extended to atraumatically extract a tooth [23]. A good example is patients who have recently received extreme doses of radiation. Such patients are highly prone to osteoradionecrosis, especially if extraction is attempted, so forced eruption could be considered the treatment of choice [23].

Another condition could be patients who have non-restorable, anterior teeth due to an extremely apical fracture line. Such remaining root surely cannot provide the required crown/root ratio, therefore extraction of the root should be considered. When the remaining root of the tooth has to be removed, surgical flaps with a considerable amount of bone removal is often necessary to provide access. This could eventually lead to the same problems encountered in surgical crown lengthening procedures, that is, loss of alveolar bone height and jeopardizing the neighboring teeth [26]. An attempt to extrude the root would be desirable, although gaining access in such circumstances would be somehow difficult. Forced eruption could also be a mixed blessing in such circumstances, as when preserving alveolar bone contour would be extremely important for improving implant sites (see next section).

Extraction of hopeless teeth and preserving soft and hard tissue dimensions with forced eruption have been accomplished successfully. It should be noted that adequate time should be allowed for tissue regeneration to occur before an extruded tooth is to be extracted [10].

Esthetic/periodontal conditions:

There is even a chance to excise discolored gingival tissue after forced eruption of a hopeless tooth with previous non precious metal restoration [28]. The discolored gingival moves into an area which is to be excised and therefore a naturally colored and positioned gingival is the result [28].

Gingival defects like recessions could also be treated with forced eruption [29]. This could be a better alternative to surgical periodontal procedures such as grafts [30].

Implant site:

The most recent application for forced eruption could be known as developing better implant sites [31].Forced eruption has been shown to be a successful treatment option for bone development in the implant site. It can be considered a more desirable alternative to other implant site development procedures such as bone grafts, guided tissue regeneration, distraction osteogenesis [32,33]. An increasing interest in the use of forced eruption and successful results have been reported [10,34].

The esthetic results of this procedure has also proved to be superior [35].

Advantages

In contrast to surgical crown lengthening procdures, it is obvious that the main advantage of forced eruption is its conservative nature [23]. Postextraction bone resorption is avoided and alveolar bone is maintained. Also, the restorative effort is kept to one tooth and the neighbor teeth are not involved 6. In comparison to surgical crown lengthening it has been said that forced eruption results in a better crown/root ratio [36,37]. Therefore, this one-tooth restoration satisfies both functional and esthetic requirements, resulting in years of additional service for the patient [38]. The process of extrusion and restoration can be accomplished in a relatively short period of time and is painless to the patient [23].
From an economic standpoint, although implants may be the best solution in some cases, there is still a patient population that may not have the financial means for receiving implant care [38].

Disadvantages

Although not serious [23], there are a few disadvantages to forced eruption:

- Esthetic temporary restoration during treatment may not be acceptable enough to the patient. Some efforts have been made in improving the esthetics which shall be discussed later.
- The procedure is time consuming, which the patient may not be willing to invest.
- Minor periodontal surgery may still be necessary if the periodontium moves with the root.

Contraindications

Guidelines could have been given in many instances to help in deciding whether a tooth is a candidate for either extraction or extrusion [39]. Some are as follows:

- Insufficient remaining root to obtain at least a 1:1 crown/root ratio. Before evaluating the crown root ratio, some factors need consideration: The optimal post length should at least equal that of the clinical crown [40], a minimal amount of 3mm of apical seal must remain, and at least 4mm of tooth structure should lie coronal to the alveolar crest to provide sufficient biologic width [41].
- Insufficient room to extrude the root the desired amount.
- Periodontal complications for a tooth to be preserved [23].
- Possible exposure of the root furcation, and increased root proximity in molars [41-43]. Posterior teeth are more amenable to surgical crown lengthening procedures [6].

Appliance designs for forced eruption

The literature shows that there are various appliances and designs for forced eruption. The reader interested in forced eruption should take extreme care before attempting for extrusion, since Improper designs or misplacement of the appliance may result in undesirable movement or tipping of some abutment teeth [23].

Before discussing the different designs used for forced eruption, it seems necessary to explain fail safe designs to the reader who is not familiar with this term.

Fail safe designs:

An important consideration in every orthodontic appliance should be its "fail-safe" property [3]. This means that, although a reasonable range of action is desired from each active force, tooth movement should stop after a prescribed range of movement even if the patient does not return for a scheduled appointment. Missed appointments or distortions in non fail safe designs mean that undesirable and excessive tooth movement might occur. In the case of forced eruption, this is equivalent to over eruption of the tooth. If not impossible, re-intruding an over-extruded tooth is extremely difficult, and the desired crown root ratio could be so easily jeopardized [41]. It seems logical to have a delay in treatment rather than a failure. Therefore it is strongly recommended to use appliance designs in forced eruption which fail safe. Cantilever springs [37], T-loop designs [27-44] are good examples of non fail safe mechanisms.

Anchorage provision

A:Removable appliances:

Successful attempts for applying forced eruption with removable appliances have been reported [46,47]. In such designs, the anchorage site is usually in the form of a hook which is incorporated into a removable plate. Most of the introduced removable designs are fail safe.
Removable appliances could be the better or even the only solution in some instances:

- When the neighbor anchor teeth have been restored with glazed ceramic surfaces [38].
- When more than one tooth is to be extruded and more anchorage is required [3].

Some disadvantages of these designs could be stated as [38]:

Manual dexterity of patient in mastering appliance activation. Removable appliances are totally dependent on the patients' cooperation and its sufficient use. Some patients somehow could not overcome the uncomfortable removable appliance or the difficulties in speech. Another main disadvantage of most removable appliance designs is that they could not be used efficiently for the retention period and a substitute is required for this stage [38]. A more recent design consisting of

a sectional removable appliance has been introduced which can overcome most of the disadvantages stated above [45].

B:Fixed appliances:

Direct bonded splints:Rigid wires which are fixed to enamel surface of the neighbor teeth is the basic design of these appliances. Some recommend these designs as intracoronal splints which span between the adjacent teeth [48]. This design places the splint exactly in line with the root canal, preventing any unwanted lateral movement. Other modifications of such designs essentially play the same role. For example, a fixed provisional could be used instead of the splint wire [49].

Bracket-splint designs:

In these designs, brackets are bonded to the neighbor (anchorage) teeth. Either a rigid archwire is engaged in the brackets to serve as anchorage [43,50] (such designs are essentially direct bonded splint designs that were previously discussed) or a flexible archwire is used in order to deliver force [10,30]. In the latter, one problem is that the anchor teeth shall also move, so it is not recommended in patients who do not wish to have orthodontic treatment [3,44]. When dealing with brackets, using rigid wire also has its own difficulties: Either the wire should be formed in such a manner that it lies passively in the brackets, which is actually impossible, or the brackets should be bonded in a manner that a straight wire could be easily engaged [3]. This means that the brackets end up in positions that have insufficient adaptation with the tooth surface, making them vulnerable to detachment. Therefore it seems unnecessary to use brackets when attempting to extrude a single tooth as adjunctive treatment.

Maintenance of hygiene is eventually one important disadvantage of fixed designs than when using removable appliances [38].

Another important disadvantage of fixed appliances could be considered its unesthetic appearance. Lingual brackets have overcome the esthetic problems but require special circumstances, which makes their use limited [28]. These appliances create posterior open bites and therefore requires wearing of a removable appliance with posterior occlusal coverage. The higher cost, interference with speech, tongue soreness, difficult oral hygiene maintenance or other difficulties of the lingual appliance [28].

It is worth noting that in some designs [7], the splint is provided in the opposite arch and traction is applied from the splint to the tooth. Such designs are definitely not fail safe.

C:Implants: Few designs exist which have utilized Implants for forced eruption procedures,either as miniscrews [51] or osseointegrated implant abutments [52] Cantilever extensions incorporated in the prosthesis serve as hooks, making it a fail safe design. The exceptional anchorage provided by osseointegrated implants makes them suitable for such purposes, since it dissipates force through the alveolar bone, and prevents undesirable tooth movements.

Tooth preparation

The tooth receiving forced eruption also requires preparation. Variety also exists in this field of tooth preparation and the point of force application. Depending on the amount of remaining tooth structure, either a bonded attachment (button, bracket cleat,...) could be bonded to remaining enamel or in cases where no enamel remains, advantage should be taken from the root canal. The details of endodontic preparation of such teeth are not in the scope of this article.

The existing options for a tooth devoid of remaining enamel could be grouped as: Wrought wire [45,48,53-55] formed into hooks and cemented into the root canal, cast hooks 38, temporary paraposts [7], hooks that could be relined with post acrylic (eg. Duralay) for better retention [54]. Where fabrication of a final core could be possible, the hook could be incorporated into the core and removed later [43,56].

Some have incorporated bonded attachments on temporary crowns for teeth without a crown for improved esthetics during the course of treatment [27,42.57].

Force delivery designs

Force Magnitude: Previous opinion was that extrusion requires extremely lighter forces in contrast to intrusion, because it was believed that the total area of the bone socket had to be resorbed for intrusion to take place, so the greatest amount of force was required for intrusion [23,58]. Based on the same idea, extrusion required the least amount of force due minimal compression of the periodontal ligament area. It was proposed from this idea that the intrusive movement of abutment teeth did not occur since the extrusive force was extremely lighter than forces required for intrusion. Today this opinion does not seem to hold true [3]. Intrusion itself requires extremely light forces and extrusion of a tooth is far easier than intrusion and could also be done with light forces. The force range for forced eruption still differs among authors, ranging from [25,38] grams of force to 250 grams [55], but as a general point, application of heavy forces is not necessary in forced eruption (extrusion) [3].

Most authors use either the various types of elastic tractions: threads [45,48,54-56] modules or ties [42,53] chain[23,43,56] bands [7,59] for applying force or by means of force created by archwire deflection [6,10,28,30,32,58]. According to force magnitude, forced eruption could be divided into two groups: slow and rapid [38]. The first category uses light forces and the tooth moves 1.0 to 2.0 mm per month [53]. Compensatory bone growth occurs during treatment. This may be desirable in areas where bone can provide a substructure for interdental

papillae or to correct a bony defect [38]. The second category, rapid extrusion, moves the tooth 3.0 - 4.0 mm per month[53]. In this case, adequate time does not exist for osseous recontouring and only changes in the gingival might be observed [38].
Although minor gingivoplasty may be necessary to achieve optimal contours [60,61], rapid forced eruption combined with fibrotomy could minimize the need for gingival recontouring at the conclusion of treatment [53].

Magnetic force:
Attractive magnets have also been employed as a more recent development [62]. One advantage is that in contrast to elastics, which in many instances fail to provide adequate initial force magnitude in short spans, magnetic force increases in shorter distances [62]. Another advantage of magnets are that they obviate the need for guiding auxillaries, imply no friction and show no fatigue [62]. One attractive magnet is embedded inside the tooth and another inside a removable appliance. One problem with magnets is their bulkiness which requires a generous amount of tooth material to be excavated [62].

Retention period:
Authors have recommended different retention periods after forced eruption, ranging between 3 weeks [50] to 6 months [54]. Some have recommended 4 weeks of retention for each millimeter of extrusion[38,63]. Simon and colleagues made a histologic investigation on dogs and observed bone formation and a normal periodontal ligament after 7 weeks [59]. Most agree that a 6-8 week period of retention is adequate [3,4,43, 48]
An additional month of retention has been recommended if the root is still mobile after 2 months [23].
Fiberotomy has been advised to minimize the risk of relapse and to reduce the retention period [62], where others are in doubt whether fibrotomy could be of any benefit at reducing retention time [38].

Esthetic considerations:
There seems that the demand of patients for esthetic appliances increases as improvements are made in appliance designs. Efforts have been made to improve the esthetics of appliances. Brackets or appliances have also been used that have less appearance and therefore have better esthetics. Some examples include lingual brackets [28]. As mentioned previously, the conventional fixed designs could also made more esthetic with provisional crowns fabricated and cemented to fill in the space during the course of treatment, or with the addition of pontics cemented to the splint only [54].

Discussion and conclusions

It could be seen that like many other fields of dentistry, no ideal method for applying forced eruption could be found. Although forced eruption is basically an easy task to perform, the operator should take care in selecting a proper method, since each design has its own benefits and deficiencies
The principles of implants as anchorage makes these designs a highly desirable alternative, but studies using this design are scarce and possibly requires more improvements.

Among all currently used fixed appliance designs, direct bonding of the splint to the enamel surface could be given higher priority [42,28], because it both eliminates the use of unsightly brackets, resulting in better esthetics and also eliminates unwanted movement of anchorage teeth.

And finally the author would like to make a recommendation to all colleagues, specially the general practitioner interested on this subject: Do not overlook the important characteristic that any forced eruption appliance should possess, that is its fail safe property.

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