The Online
ANGLE ORTHODONTIST
An International Journal of Orthodontics and Dentofacial Orthopedics
78th Anniversary 1930–2008

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doi: 10.2319/0003-3219(2008)078[0752:ISDBOE]2.0.CO;2
***The Angle Orthodontist:* Vol. 78, No. 4, pp. 752–760.**

Implant Site Development by Orthodontic Extrusion

A Systematic Review

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ABSTRACT

Objective: To determine the effectiveness of orthodontic extrusion of nonrestorable teeth prior to implant placement for improving the alveolar bone and gingival characteristics of implant recipient sites.

Materials and Methods: Electronic database searches of the following databases were conducted with the help of a senior health sciences librarian: Medline, PubMed, EMBASE, Scopus, Web of Science, and CINAHL Plus. Hand searches of the reference lists of selected articles were also conducted. Abstracts that appeared to fulfill the initial selection criteria were selected for full article retrieval. Retrieved articles were then carefully evaluated, and more specific selection criteria were applied. The authors conducted the selection processes independently, and any differences were resolved through discussion. An analysis of timing, type, and magnitude of forces applied was sought.

Results: Eighteen articles were considered for review. Most of the selected articles were case reports or case series describing orthodontic extrusion of periodontally hopeless maxillary anterior teeth. The results of the reported cases were evaluated individually and collectively with regard to various hard and soft tissue implant site characteristics. Clinically significant gains in alveolar bone and gingival tissue were reported in all cases, resulting in significant quantitative and qualitative improvements in the implant sites.

Conclusions: Based on the available literature, orthodontic extrusion of nonrestorable teeth prior to implant placement appears to be a viable alternative to conventional surgical augmentative procedures in implant site development. No direct comparison to any other method was found, and therefore no conclusion could be made about its relative efficacy.

KEY WORDS: Implant site, Orthodontic extrusion.

Accepted: September 2007. Submitted: July 2007

INTRODUCTION Return to TOC

The quality and quantity of alveolar bone and gingival tissues in potential implant recipient sites is a major determinant of the long-term prognosis of the implant fixture. The primary stability of a dental implant is directly related to the amount of alveolar bone available at the time of implant placement. Implants should be placed in pre-existing bone, while regenerative bone should not be relied on for primary support but merely to obtain coverage.[1]

The three-dimensional morphology of the alveolar bone in potential implant sites is often less than ideal, especially in the anterior region. The inadequate amount of cortical bone in the buccolingual dimension often necessitates surgical or nonsurgical bone augmentation to ensure ideal implant positioning and adequate thread coverage. In cases of immediate implant placement following tooth extraction, the extraction socket left behind immediately after tooth extraction is invariably too large to closely approximate the implant surface, especially in the coronal two-thirds. The conical shape of the socket also precludes a tight fit around the generally cylindrical implant, a problem that is compounded by the almost inevitable coronal socket expansion that occurs during extraction maneuvers.[2]

Augmentative surgical procedures are often used to improve the hard and soft tissue profiles of implant recipient sites. Allogenous grafting and autogenous bone grafting from intraoral or extraoral donor sites is currently the most widely used and best studied method of increasing the amount of alveolar bone available for primary implant anchorage, stability, and thread coverage. For correction of gingival deficiencies at potential implant recipient sites, conventional mucogingival surgical procedures, such as connective tissue grafts, free gingival grafts, and coronally positioned flaps, are the mostly commonly used treatment modalities.[3]

In 1993, orthodontic extrusion of nonrestorable “hopeless” teeth prior to extraction and subsequent implant placement was introduced as a viable alternative.[4] In a later series of articles, osteophysiologic and soft tissue responses to orthodontic extrusion, as observed and measured in a series of clinical cases, were described.[5,6]

Thereafter, several publications dealt with the use of orthodontic extrusion as a means to improve future implant sites. Differences in treatment timelines, direction and magnitude of forces, and extrusion biomechanics are found in the literature.

This article aims to determine the effectiveness of orthodontic extrusion as a nonsurgical method of improving the local hard and soft tissue profiles of implant recipient sites based on a systematic review of the current evidence. A comprehensive understanding of the relative advantages and disadvantages of these techniques is warranted to shed some light on this

emerging treatment modality and to help the clinician understand the multiple proposed techniques to develop the implant site through orthodontic means to guide case selection and treatment-planning decisions in their specific clinical situations.

MATERIALS AND METHODS Return to TOC

The literature searches conducted for this review consisted of searches of six different electronic databases as well as hand searches of the reference lists of the selected articles. Details of the search methodology and selection process are described below.

The specific search terms used in each database were selected with the aid of a senior librarian specializing in health sciences database searches. Basically, relevant terms were identified based on prior knowledge of the subject matter and the Medical Subject Heading (MeSH) information provided in MeSH-based electronic databases (Medline, PubMed, and EMBASE). The terms used to describe the technique or interventions in question were *orthodontic extrusion, tooth extrusion*, and *forced eruption.* The terms used to associate these interventions with the proposed outcome were *alveolar ridge, alveolar bone*, and *implant.* Terms were truncated and combined appropriately according to the database being searched. Whenever possible, similar search strategies were used in each database. The electronic database searches were not limited by language, type of study, or any other available limits or restrictions (Table 1). The last updated search was July 14, 2007.

The selection of articles for this systematic review was a two-phase process with specific inclusion and exclusion criteria for each phase. These criteria are outlined in Table 2. All of the abstracts were reviewed independently by each author and subjected to the first phase of the selection process. Once potentially adequate abstracts were identified, their full articles were retrieved. Thereafter, the second selection criteria were applied. The authors performed each phase of this selection process independently, and any discrepancies were resolved through discussion and consensus. Reference lists of the finally selected articles were hand searched for any article that could have been missed in the electronic databases.

RESULTS Return to TOC

The results of these searches yielded a total of 79 unique abstracts, of which 61 were eliminated in the first selection phase, leaving 18 abstracts for which 17 full-text articles could be retrieved. One abstract that appeared to be potentially useful appeared not to have been published as a full article.[7] Upon evaluation of the 17 retrieved articles, two articles were later excluded in the second phase of selection. These two articles were found to be general reviews or discussion articles on orthodontic extrusion, with no particular focus on implant site development.[8–10] Hand searching of the reference lists of the resulting 15 articles led to three more articles that met the selection criteria and were retrieved, for a final total of 18 articles selected for review. A flow diagram of the selection process can be found in Figure 1.

Most of the articles selected for this review (15 of 18) were case reports. An article was deemed to be a case report or a report on a series of cases when it was explicitly stated as such in the title or when the article was found to focus primarily on a clinical case (or series) with only a minor discussion of the literature. The three non–case report articles selected were review papers, one introducing the concept of implant site development by orthodontic extrusion and a classification system for extraction sockets[4] and the other two describing and analyzing the osteophysiologic and soft tissue responses to that technique based on the close observation of five clinical cases.[5,6] A synopsis of all the reported cases is presented on Table 3.

In all, 19 individual cases in which orthodontic extrusion was performed for implant site development have been reported in the literature thus far. This is in addition to the five cases studied by Mantzikos and Shamus.[5,6] In one of the selected articles, the authors indicated that they have used this technique to treat more patients than are reported in the article, but no specific information is provided on those other cases.[11] The patients in the 19 reported cases ranged in age from 19 to 62 years and included 10 women and 4 men. Gender was not reported for five patients, and age was not reported in three of those cases.

A total of 23 teeth underwent extrusion for the purpose of extraction and subsequent implant placement in the current sample of 19 cases. The overwhelming majority of these teeth were maxillary anterior teeth, including 14 central incisors, four canines, and three lateral incisors. One case involved the extrusion of three posterior maxillary teeth.[22] Only one mandibular tooth, a left second premolar, was reported.[12]

By far, the most common cause for extraction was a very poor or hopeless periodontal prognosis. The teeth in question invariably had severe horizontal bone loss and interproximal or circumferential vertical bone defects. The amount of remaining alveolar bone support ranged from the apical third of the root to less than 10%. Excessive tooth mobility and large probing depths were reported in most cases. Despite the extensive periodontal destruction that characterized most of the subject teeth, most authors indicated that all active periodontal inflammation was brought under control with aggressive periodontal therapy and confirmed on follow-up prior to the initiation of any orthodontic movement. In the few articles in which the periodontal treatment was not discussed, no mention was made as to the status of the periodontal disease and inflammation at the time of orthodontic extrusion, although it is presumed to have been successfully treated given the results achieved in those cases. Three teeth were deemed nonrestorable because of extensive decay, root fractures, or unsuccessful previous dental treatment. These were also extruded and extracted in a similar fashion to the ones lost to periodontal disease.

In all but two of the cases, fixed orthodontic appliances were used to impart the extrusive force. The two exceptions involved the use of extrusive components integrated into provisional restorations.[4] In the fixed appliance cases, conventional bonded brackets were used, with brackets positioned more apically than adjacent (anchor) teeth to effect the extrusion. Several cases reported the use of two separate arch wires simultaneously: a lighter nickel-titanium active wire and a heavier stainless steel anchorage wire. To maintain the extrusive force on the tooth throughout the active phase of treatment, some clinicians repositioned the bracket incrementally more apically at regular intervals, some placed vertical step bends in the arch wire, and others simply positioned the active wire apical to the bracket (outside the slot) and added increments of composite to the apical aspect of the brackets to maintain the activation of the wire. Authors also reported grinding down the occlusal/incisal aspects of the extruded teeth to avoid occlusal interferences as the teeth moved coronally, with some teeth requiring endodontic treatment because of the extent of reduction required. Removable appliances were not used in any of the cases reported.

Treatment time lines varied considerably among the cases reported. The active phase of orthodontic extrusion (the period during which an eruptive force was maintained on the tooth) ranged from 4 weeks[14] to 28 weeks[22] (mean, 12.8 weeks). The retention/stabilization phase (the period during which the extruded tooth was held passively in position) ranged from 0 days[14,15] (immediate extraction at the end of active extrusion) to 6 months[1,2] (mean, 9.3 weeks). In most cases, implants were placed immediately after atraumatic tooth extraction; however, in some cases, a healing period of 2 to 8 weeks was allowed before implant placement.[1,11,16–18] Following implant placement, a 6-month healing/osseointegration period was allowed in most cases prior to implant loading (with a coronal restoration). Three cases indicated shorter healing periods ranging from 1 to 4 months.[1,9,22] In one reported case, a healing period of 41 months was allowed prior to restoration,[12] and in another case, single-stage implant therapy was performed, with immediate loading of the implant following placement.[20]

DISCUSSION Return to TOC

For the purposes of this discussion, the term *orthodontic extrusion* is used and considered synonymous with all the similar terms used in the literature, such as *forced eruption, orthodontic extrusive remodeling,* and *orthodontic extraction* (defined variably as extrusion of the root beyond the confines of the alveolus or rapid extrusion of the root through the alveolus without the accompaniment of the remaining periodontal attachment apparatus). We use this term to refer to the controlled movement of a tooth and/or root in a coronal direction along the long axis under the effects of a sustained orthodontic force in a physiologic manner maintaining the existing periodontal attachment apparatus.

All case reports included in this review described both hard and soft tissue changes in response to orthodontic extrusion. Improvements to the implant recipient site, in the form of qualitative and quantitative gains in the alveolar bone and gingival tissue, were reported in all cases. However, these changes were quantified only by Mantzikos and Shamus,[5,6] who measured the observed hard and soft tissue changes in a calibrated manner on five clinical cases selected for their study. Apical alveolar bone deposition leading to partial or complete bone fill of the extraction socket was demonstrated in all of the reported cases, with many authors also reporting additional alveolar bone level increases in both vertical and buccolingual dimensions. Coronal migration of the free gingival margin and/or increases in the width of the attached gingiva were also reported in all cases, and several studies also reported

increases in the vertical height of the interdental papilla on the mesial and/or distal aspect of the extruded tooth. Most of the reported teeth were maxillary incisors.

Although variations in treatment time lines are likely attributable to the various individual characteristics unique to each case, the authors feel that there is no generally accepted consensus on a standard clinical protocol to follow with regard to orthodontic extrusion for the purpose of implant site development, in terms of the need for and length of the retention phase, its relationship to the active phase, and the need for and length of a healing period following tooth extraction prior to implant placement. These decisions appear to have been made on an empirical basis in most cases.

Despite the variations in treatment protocols followed during the orthodontic phase of treatment, we were able to establish several general clinical guidelines for this phase of treatment based on orthodontic treatment-planning patterns identified in the literature. These guidelines are the following:

Light, constant, extrusive forces are recommended: 15 g for anterior teeth to 50 g for posterior teeth.

The extrusion rate is to be maintained at a slow and steady rate of no more than 2.0 mm per month.

A buccal root torque component may be applied concomitantly to increase the buccolingual bulk of alveolar bone.

A retention and stabilization period of no less than 1 month for every month of active extrusion is recommended prior to extraction.

Overlay wires (anchorage wires) are recommended to reinforce anchorage and avoid tipping of adjacent teeth toward the tooth undergoing active extrusion.

In all but five of the cases examined in this review, no additional soft or hard tissue augmentative procedures were performed in addition to orthodontic extrusion, as the resultant implant recipient site was deemed clinically adequate in those regards at the time of tooth extraction. However, in three cases, gingival grafting procedures were performed to augment the soft tissue profile of the implant site (two connective tissue grafts, one free gingival graft).[11,13] In one case, demineralized freeze-dried cortical bone and an overlying Gore-Tex membrane were used to cover labial dehiscences and exposed crestal threads of two maxillary central incisor implants.[1] Autogenous bone grafting on the anterior aspect was used on another case with two maxillary incisor implants.[9]

The long-term results reported in the literature selected for this review demonstrate stability and clinical success. Reported follow-up periods ranged from 7 months[9] to more than 3 years.[14] No authors reported a need for any further surgical or nonsurgical revisions once the definitive restoration was permanently affixed to the underlying abutment. Where it was reported, the radiographic follow-up also showed evidence of successful osseointegration of the implant with no loss of crestal bone from the time of implant placement.

The present systematic review represents scientific evidence that can only be as strong as the individual case reports reviewed within it and their collective anecdotal and empirical value. Some of the limitations inherent in this type of study include the fact that no failures are likely to be reported. The readers must assume that complete failures do occur, as do instances in which orthodontic extrusion is only minimally successful or makes a clinically negligible difference. Also, the lack of a standardized clinical treatment protocol to be followed among the cases and the lack of quantitative data about the outcomes of treatment limit the number and strength of the conclusions that can be drawn.

Further research is necessary to reliably establish what, if any, benefit orthodontic extrusion may provide in the development of implant recipient sites in areas of moderate to severe periodontal destruction. Such research could include a blind comparison to other more commonly accepted treatment modalities for compromised implant sites, such as autogenous or allogenous bone grafting, guided tissue regeneration, and mucogingival augmentative procedures. Several authors of selected articles noted that the total treatment time is no longer, and may in fact be shorter, with orthodontic extrusion than with surgical augmentation.[3,4,14] However, there was no actual clinical comparison conducted between orthodontic extrusion and any other treatment modality in any of the reported cases. Clinical trials comparing the qualitative and quantitative regenerative potential of orthodontic extrusion to that of conventional augmentative surgical procedures can be designed and conducted relatively easily. The risk-benefit ratio and cost-effectiveness of this treatment modality can also be more clearly established through such trials.

CONCLUSIONS Return to TOC

- Based on the available literature, orthodontic extrusion of nonrestorable teeth prior to implant placement appears to be a viable alternative to conventional surgical augmentative procedures in implant site development.
- Since no direct comparison to any other method was found, no conclusion can be made about its relative efficacy compared with other methods.

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Table 1. Electronic Database Search Terms and Strategies

Database		Keywords/Search Strategy	Results
Medline 1966–present	1	(Orthodontic Extrusion$ OR Tooth Extrusion$ OR Forced Eruption$).mp.	203
	2	(Alveolar Ridge$ or Alveolar Process$).mp.	10,182
	3	implant$.mp.	207,713
	4	1 AND 2	31
	5	1 AND 3	38
	6	4 OR 5	56
PubMed	1	Orthodontic Extrusion* OR Tooth Extrusion* OR Forced Eruption*	208
	2	Alveolar Ridge* or Alveolar Process*	10,255
	3	implant*	180,416
	4	1 AND 2	32
	5	1 AND 3	33
	6	4 OR 5	51
EMBASE (Ovid)	1	(Orthodontic Extrusion$ or Tooth Extrusion$ or Forced Eruption$).mp.	8
	2	(Alveolar Ridge$ or Alveolar Process$).mp.	693
	3	implant$.mp.	122,082
	4	1 AND 2	3
	5	1 AND 3	3
	6	4 OR 5	3
Scopus	1	Orthodontic Extrusion* OR Tooth Extrusion* OR Forced Eruption*	65
	2	Alveolar Ridge* or Alveolar Process*	7899
	3	implant*	268,033
	4	1 AND 2	6
	5	1 AND 3	9
	6	4 OR 5	12
Web of Science	1	Orthodontic Extrusion* OR Tooth Extrusion* OR Forced Eruption*	298
	2	Alveolar Ridge* or Alveolar Process*	4571
	3	Implant*	>100,000
	4	1 AND 2	8
	5	1 AND 3	25
	6	4 OR 5	30
CINAHL Plus	1	(Orthodontic Extrusion$ OR Tooth Extrusion$ OR Forced Eruption$).mp.	17
	2	(Alveolar Ridge$ or Alveolar Process$).mp.	49
	3	implant$.mp.	8944
	4	1 AND 2	3
	5	1 AND 3	7
	6	4 OR 5	9
Total number of results (sum of all results)			160
Total number of unique results			

(sum minus duplicates)	79

Table 2. Selection Criteria

Inclusion Criteria	Exclusion Criteria
First selection phase (79 abstracts)	
Journal articles, including clinical trials, case reports, and case series	Letters, editorials, theses, abstracts, other types of publications
Contains one or more of the search terms in the title	Articles focusing on orthodontic extrusion for any purpose other than implant site development
Primary focus of the article is orthodontic extrusion for the specific purpose of implant site development for subsequent implant placement	Studies on alveolar bone augmentation using orthodontic extrusion, without subsequent implant placement
Second selection phase (18 articles)	
Articles describing hard and/or soft tissue changes of implant recipient sites following orthodontic extrusion	Articles describing only techniques used for orthodontic extrusion
Full-text article is retrievable and available in English	Any articles in which a clear source of bias or other major methodological errors could be identified
	Articles whose full text could not be retrieved despite the authors' best efforts

Table 3. Synopsis of Case Reports

Lead Author	Patient	Tooth No.	Case	Treatment
Biggs[15]	Not provided	21	Periodontally hopeless tooth, circumferential vertical bone loss, and poor crown-to-root ratio	Orthodontic intrusion initially to gain more hard and soft tissue coverage of the root, followed by extrusion and extraction with immediate implant placement
Buskin[2]	Case 1: 60-year-old man	22	Extensive coronal and subgingival caries; advanced periodontal disease	Orthodontic extrusion followed by orthodontic extraction of no. 22, then atraumatic extraction followed by immediate implant placement
	Case 2: 55-year-old man	21	Recurrent subgingival caries beneath existing crown	5-mm orthodontic extrusion of no. 22, followed by extraction and immediate implant placement
Celenza[16]	Not provided	11, 21	Periodontally hopeless; bilateral interproximal horizontal and vertical bone defects	Orthodontic extrusion of both central incisors over a 12-wk period, followed by 8 wk of healing and remodeling before implant placement
Chambrone[17]	48-year-old man	12	Infrabony vertical root fracture with existing cast-gold core and ceramometal crown	Orthodontic extrusion using fixed appliance with two wires (active wire and anchorage wire) followed by extraction and immediate implant placement
Chandler[18]	26-year-old woman	21	Circumferential periodontal defect with Class II+ mobility; history of trauma	Root canal therapy on no. 21 followed by 3-mm orthodontic extrusion; implant placed after 6-wk healing period
Danesh-Mayer[13]	19-year-old Asian woman	11	Mild-to-moderate postjuvenile periodontitis; lo-	Comprehensive periodontal therapy, followed by

			calized areas of severe periodontitis; only 5%–10% of bone remaining around apex	orthodontic extrusion of no. 11, with subsequent extraction and immediate implant placement with connective tissue graft to augment buccal gingiva
Erkut[22]	62-year-old Caucasian woman	14, 16, 17	Severe periodontal inflammatory disease with interproximal bone loss, mobility; poor periodontal prognosis	Periodontal therapy; 7 mo of orthodontic treatment including extrusion of teeth no. 14, 16, and 17; extraction and immediate implant placement; 4 mo of healing; 3-unit bridge
Gonzalez-Lopez[14]	34-year-old woman	11	Severe external resorption, severe gingival recession, and alveolar bone loss	Extraction of the detached coronal 2/3 of the root; orthodontic extrusion of the remaining apical fragment with subsequent extraction and immediate implant placement

Table 3. Continued

Lead Author	Patient	Tooth No.	Case	Treatment
Lin[19]	25-year-old Asian woman	11	Periodontally hopeless; external resorption and loss of interdental papilla	Orthodontic extrusion of the affected incisor, followed by extraction and immediate implant placement; 6-mo healing period to follow
Mantzikos[1]	34-year-old Caucasian man	11, 21	Periodontally hopeless; proclined with vertical and horizontal bone loss	Comprehensive periodontial treatment. Extrusion and retraction of both central incisors; extraction followed by 4-wk healing period before implant placement
Mantzikos[5] (Osteophysiologic) Mantzikos[6] (soft tissue)	Five selected clinical cases observed for further study and reported separately from an osteophysiologic and soft tissue perspective	11, 21	Poor periodontal prognosis, planned for extraction	Fixed orthodontic appliances used in all cases to extrude maxillary central incisors with simultaneous incisal reduction for a period of 16 wk
Nozawa[12]	45-year-old woman	35	Periodontally hopeless; Class II mobility, angular bone defects, severe buccal bone resorption; history of failure of surgical periodontal treatment	Orthodontic extrusion (15 mm) with buccal root torque (90°), followed by 8-wk stabilization period, free gingival graft, and frenectomy; then extraction and immediate implant placement
Ostojic[9]	44-year-old woman	11, 21	Traumatic fractures of both teeth 35 y prior, restored with crowns that were too long, presents with extensive vertical and horizontal bone loss	Ortho extrusion of both teeth, followed by extraction and immediate implant placement with autogenous bone grafting to the anterior aspect of the implant
Park[20]	41-year-old woman	21	Periodontally hopeless; severe alveolar bone loss; Class III mobility	Orthodontic extrusion using fixed appliance, followed by extraction and

				immediate implant placement and loading
Salama[21]	Three clinical cases presented in summary for demonstration	13, 23, 13, 13	Various situations leading to severe horizontal and vertical circumferential bone defects	Orthodontic extrusion using fixed appliances and/or active components built into provisional restorations; extraction upon completion of the extrusion phase and immediate implant placement
Salama[4]	24-year-old woman	21	Traumatic fracture, failure of subsequent unsuccessful endodontic treatment, based on diagnosis of endodontic-periodontal lesion	Orthodontic extrusion of the incisor for 6 wk followed by 7-wk stabilization period; extraction and immediate implant placement
Zucatti[11]	20-year-old woman (other similar cases mentioned briefly in this article but not formally reported)	21	History of early trauma and apicoectomy; buccal gingival recession and bone loss to the level of the apex	Orthodontic extrusion and buccal root torque of the affected incisor; 2-mo retention period, extraction, then 2-mo healing period before implant placement

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Figure 1. Flow diagram of literature search

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