REVIEW ARTICLE

Critical factors for the success of orthodontic mini-implants: A systematic review

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Introduction: This systematic review was undertaken to discuss factors that affect mini-implants as direct and indirect orthodontic anchorage. **Methods:** The data were collected from electronic databases (Medline [Entrez PubMed], Embase, Web of Science, Cochrane Library, and All Evidence Based Medicine Reviews). Randomized clinical trials, prospective and retrospective clinical studies, and clinical trials concerning the properties, affective factors, and requirements of mini-implants were considered. The titles and abstracts that appeared to fulfill the initial selection criteria were collected by consensus, and the original articles were retrieved and evaluated with a methodologic checklist. A hand search of key orthodontic journals was performed to identify recent unindexed literature. **Results:** The search strategy resulted in 596 articles. By screening titles and abstracts, 126 articles were identified. After the exclusion criteria were applied, 16 articles remained. The analyzed results of the literature were divided into 2 topics: placement-related and loading-related factors. **Conclusions:** Mini-implants are effective as anchorage, and their success depends on proper initial mechanical stability and loading quality and quantity. (Am J Orthod Dentofacial Orthop 2009;135:284-91)

The growing demand for minimum compliance and maximum curative effects has made the temporary anchorage device (TAD) more promising as an excellent alternative to traditional orthodontic anchorage. Endosseous dental implants have served successfully as anchorage structures for orthodontic appliances, especially in patients whose dental elements lack quantity or quality.[1] Tipped mandibular second molars were uprighted with implants in a third molar extraction site.[2] Palatal implants have been used to reinforce anchorage in Angle Class II malocclusion patients in whom retraction of anterior teeth was achieved after the maxillary first premolars were extracted.[3] However, because of their disadvantages—complicated surgical procedure, long healing time, and limited implant sites—they are difficult to use as routine clinical anchorage.

In 1983, Creekmore and Eklund[4] placed a vitallium screw in the anterior nasal spine of a patient with a deep impinging overbite to intrude the maxillary incisor. Although the clinical results were exciting, the technique did not gain immediate acceptance because it was premature to be used clinically without an adequate understanding of reliability or pathology. In 1997, Kanomi[5] reported a successful case with a mini-screw (diameter, 1.2 mm; length, 6 mm), with the mandibular incisors intruded 6 mm with no root resorption or periodontal pathologic evidence. Park[6] then presented a case using 1-stage surgical microscrews with healing in an open method in 1999, generating serious interest in mini-implants as a source of skeletal anchorage because of their superiority for few anatomic limitations, simple placement, and versatile applications.[7] Surgical microscrews have been substituted for specially designed orthodontic mini-implants that are more suitable as conventional orthodontic anchorage fixtures.[8]

The generally accepted protocol for successful and predictable placement of mini-implants includes atraumatic surgical technique, short healing period, biocompatible materials, and patient management.[9] To encourage regeneration and osseointegration, rather than repair with fibrous encapsulation, a primary healing environment at the bone-implant surface should be created.[10]

The aims of this article were to review and critically analyze the available literature about mini-implants (screws) and to discuss, based on scientific evidence, factors that might influence this modality with immediate or early loading.

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MATERIAL AND METHODS

The method for this review was based on the guidelines published in the *American Journal of Orthodontics and Dentofacial Orthopedics*,[11] and a cross-disciplinary systematic review was conducted according to the recommendations of the National Health Service Center for Reviews and Dissemination.[12] Internationally published research literature, review articles, bibliographies, and relevant citations in articles in all languages were included, and databases were searched back to their inception. In the initial phase of the review, a computerized literature survey was performed by searching the MEDLINE database (Entrez PubMed, www.ncbi.nlm.nih.gov) (from 1966 to week 3 of June 2007), the Cochrane Library (www.cochrane.org/reviews), and the CRD Database of Ongoing Reviews to find systematic reviews, meta-analyses, and literature reviews. Terms used in this literature search were *mini-implant, mini-screw, micro-implant, microscrew, screw, temporary anchorage device (TAD); orthodon; immediate, early,* and *loading*.

Additionally, after the electronic literature search, a hand search of key orthodontic journals was undertaken to identify recent unindexed articles.

The review was restricted to peer-reviewed articles dealing with mini-implants, when the implant diameter was smaller than 2.5 mm.[13] The following inclusion criteria were initially used to select appropriate articles: articles on mini-implant (screw) and microimplant (screw) used as orthodontic anchorage, data only from human subjects, language in English, randomized controlled studies (RCTs), prospective clinical studies, and retrospective clinical studies.

Exclusion criteria included articles on standard dental implants, onplants, palatal implants, miniplates used as orthodontic anchorage, miniscrews or microscrews for dental surgery, and implant materials research; animal studies; in-vitro studies; case reports and case series; technique presentations of mini-implant and microimplant; review articles and letters; articles that did not follow the objective of this review; and articles in a language other than English.

Data collection and quality analysis

Data from the retrieved studies were collected based on year of publication, study design, materials (implant materials, shape, diameter, length), implant number, loading quantity, healing period, treatment or observation duration, success rate, posttreatment observation, and authors' conclusions.

The eligibility of the articles identified by search engines was determined by reading their titles and abstracts. Two reviewers (Y.C. and W.T.Z.) independently assessed all articles with respect to the inclusion and exclusion criteria, and the kappa score measuring the level of agreement was 0.88. The data were extracted from each article separately without blinding to the authors, and intraexaminer conflicts were resolved by discussing each article to reach a consensus. All articles that appeared to meet the inclusion criteria on the basis of their abstracts in which relevant information was provided were also retrieved.

A quality evaluation of the methodologic soundness of each article was performed for the RCTs according to the methods described by Feldmann and Bondemark,[14] with an extension of the quality appraisal to controlled clinical trials. The following characteristics were used: study design, sample size and prior estimate of sample size, valid measurement methods, method-error analysis, blinding in measurements, adequate statistics, and confounding factors. Ten variables were evaluated in the study: RCT, 3 points; prospective study, 1 point; retrospective study, 0 point; adequate sample, 1 point; previous estimate size, 1 point; adequate selection description, 1 point; method-error analysis, 1 point; blinding in measurement, 1 point; adequate statistics provided, 1 point; and confounders included in analysis, 1 point. The quality of each study was categorized as low (0-4 points), medium (5-8 points), or high (9-11 points).

RESULTS

Electronic and hand searches identified 596 titles and abstracts on implants as anchorage, of which 470 were excluded at the first stage according to the inclusion criteria. The remaining 126 articles, for which the abstracts seemed to be potentially useful, were retrieved. Twenty-one studies actually fulfilled the initial selection criteria after we read the complete article. At the final stage of article selection, 5 were rejected because they were case series. Finally, only 16 articles that met all inclusion criteria remained.[7,9,15-28] A flow diagram of the literature search is shown in the Figure. A methodologic quality checklist was used to evaluate the selected articles (Table I). Data about the 16 studies are listed in Table II, and a qualitative analysis of sample size, loading period, and success rate is also given.

Placement methods

From the 16 studies selected for this study, the self-tapping placement method was used in 14.

The relationship between the diameters of the pilot drill and the implant shows that, in 6 of the 14 studies, a 1.5-mm diameter pilot drill was used for the 2.0-mm diameter implants[15,20,23-26]; the survival rates were 85%[15] to 100%.[23] Costa et al[15] reported that 2 of 16