Review Article

Implant vs Screw Loading Protocols in Orthodontics

A Systematic Review

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ABSTRACT

Objective: This systematic review presents the loading protocols applied when using implants and/or screws in orthodontic treatments.

Materials and Methods: Clinical trials which assessed the use of implants and/or screws for orthodontic anchorage and studies involving treatment on syndromic patients, surgery, other simultaneous treatments, or appliances (ie mini-plates) were considered. Electronic databases (Medline, Medline In-Process & Other Non-Indexed Citations, Lilacs, Pubmed, Embase, Web of Science, and All Evidence Based Medicine Reviews) were searched with the help of a senior Health Sciences librarian. Abstracts which appeared to fulfill the selection criteria were selected by consensus. The original articles were then retrieved and evaluated with a methodological checklist. References were also hand searched for possible missing articles.

Results: Eleven articles fulfilled the selection criteria established. Five studies involved the use of implants while six involved the use of screws for orthodontic purposes. An individual methodological analysis for each article was made.

Conclusions: Loading protocols for implants involve a minimum waiting period of 2 months before applying orthodontic forces while loading protocols for screws involve immediate loading or a waiting period of 2 weeks to apply forces. Success rates for implants were on average higher than for screws. (*Angle Orthod* 2006;76:721–727.)

Key Words: Implants; Screws; Temporary anchorage devices; Orthodontic loading

INTRODUCTION

The use of implants in dentistry began when Branemark et al[1] published the success of osseointegrated titanium endosseous implants. Implants in dentistry are mostly used for prosthetic reasons,[2] but in the past two decades, they have been incorporated into the orthodontic field for anchorage purposes.[2–5]

Extraoral headgear has been considered an effective form of orthodontic anchorage[6] but depends on patient cooperation, and treatment results are limited without it.[4,6,7] For this reason, other alternatives have been developed like intraoral appliances such as implants. Nevertheless, to use implants, good and sufficient bone structure is necessary for their placement.[8,9] To overcome this disadvantage, smaller appliances such as mini-implants and screws are being developed.[4,5]

Although implants and screws seem to be effective alternatives for anchorage in orthodontics, there are some factors to consider before using them. All these appliances should be correctly osseointegrated or fixed to apply force on them.[7] To obtain this osseointegration or fixation, a period of time has to be determined where no force would be applied on these devices and, thus, reducing the risk of failure.[6] Nevertheless, some studies[3,7,10] have stated that forces can be applied immediately after the placement of such devices. This creates a controversy regarding the protocol on the use of implants and screws after their insertion in the mouth for orthodontic purposes.

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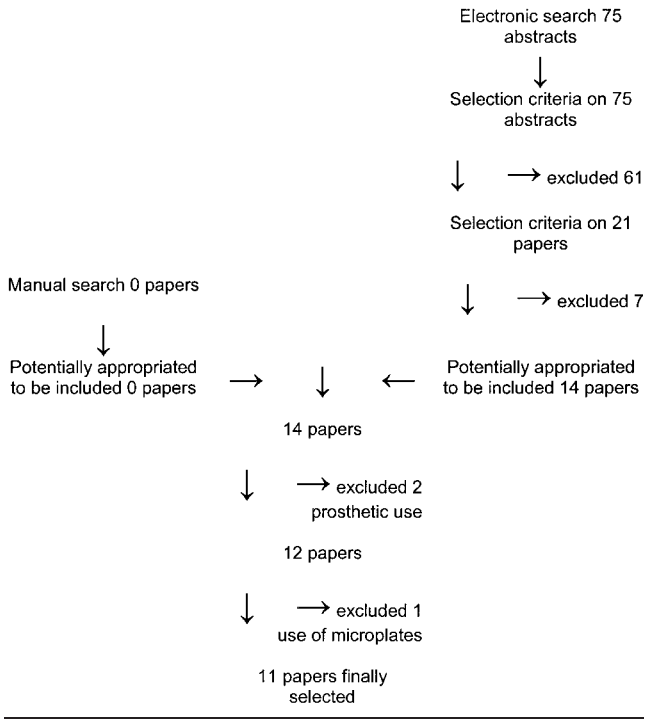
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TABLE 1. Search Results from Different Databases

Database	Key Words	Results	Selected	% of Total Selected Abstracts (21)[a]
PubMed	(1) implant[a]; (2) screw[a]; (3) temporary anchorage device[a]; (4) load[a]; (5) orthodon[a]; (6) 1 or 2 or 3; (7) 6 and 4 and 5; (8) limit to human	59	16	76.2
Medline	(1) implant$.mp; (2) screw$.mp; (3) temporary anchorage device$.mp; (4) load$.mp; (5) orthodon$.mp; (6) 1 or 2 or 3; (7) 6 and 4 and 5; (8) limit to human	54	16	76.2
Medline In-Process & Other Non-Indexed Citations	(1) implant$.mp; (2) screw$.mp; (3) temporary anchorage device$.mp; (4) load$.mp; (5) orthodon$.mp; (6) 1 or 2 or 3; (7) 6 and 4 and 5; (8) limit to human	1	0	0
Embase	(1) implant$.mp; (2) screw$.mp; (3) temporary anchorage device$.mp; (4) load$.mp; (5) orthodon$.mp; (6) 1 or 2 or 3; (7) 6 and 4 and 5; (8) limit to human	5	2	9.5
All EBM reviews (Cochrane Database of Systematic Reviews, ASP Journal Club, DARE and CCTR)	(1) implant$.mp; (2) screw$.mp; (3) temporary anchorage device$.mp; (4) load$.mp; (5) orthodon$.mp; (6) 1 or 2 or 3; (7) 6 and 4 and 5; (8) limit to human	2	1	4.8
Web of Science	(1) TS = (implant[a]); (2) TS = (screw[a]); (3) TS = (temporary anchorage device[a]); (4) TS = (load[a]); (5) TS = (orthodon[a]); (6) #1 or #2 or #3; (7) #6 and #4 and #5 DocType = Article; Language = All languages; Database(s) = SCI-Expanded, SSCI, A&HCI	36	12	57.1
Lilacs	(1) implant; (2) screw; (3) temporary anchorage device; (4) load; (5) #1 or #2 or #3; (6) #4 and #5	10	0	0

[a] Percentages do not add up to 100% as the same reference could be found in several databases.

TABLE 2. Flow Diagram of the Literature Search



The purpose of the present systematic review is to present the loading protocols applied when using implants or screws (or both) in orthodontic treatments on the basis of all available published scientific literature that met predetermined minimum criteria for study design.

MATERIALS AND METHODS

Terms used in the literature search consisted of implant, screw, temporary anchorage device, load, orthodontic, and their respective abbreviations according to the search engine used. The selection of these terms was made with the assistance from a senior librarian, specialized in Health Sciences databases. Inclusion criteria to apply on the initial selection of the appropriate articles from the published abstracts consisted of human clinical trials, implant/screw use for orthodontic purposes, nonsyndromic patients (ie, cleft patients), and no surgical or other simultaneous treatment, which could affect the implant/screw integrity during the evaluation period.

A computerized search was conducted using Medline (from 1966 to week 3 of May 2005), Medline In-Process & Other Non-Indexed Citations (from week 3 of May 2005 to week 4 of May 2005), Lilacs (from 1982 to May 2005), PubMed (from 1966 to week 3 of May 2005), Embase (from 1988 to week 22 2005),

TABLE 3. Methodological Score for the Clinical Trials

I. Study design (9√)
- A. Objective—objective clearly formulated (√)
- B. Population—described (√)
- C. Selection criteria—clearly described (√); adequate (√)
- D. Sample size—considered adequate (√); estimated before collection of data (√)
- E. Baseline characteristics—similar baseline characteristics (√)
- F. Timing—prospective (√)
- G. Randomization—stated (√)

II. Study measurements (5√)
- H. Measurement method—appropriate to the objective (√)
- I. Blind measurement—blinding (examiner √, statistician √)
- J. Reliability—described (√), adequate level of agreement (√)

III. Statistical analysis (6√)
- K. Dropouts—dropouts included in data analysis (√)
- L. Statistical analysis—appropriate for data (√); combined subgroup analysis (√)
- M. Confounders—confounders included in analysis (√)
- N. Statistical significance level—*P* value stated (√); confidence intervals (√)

Maximum number of √s = 20

Web of Science (from 1945 to week 3 May 2005), and all EBM reviews (Cochrane Database of Systematic Reviews, ASP Journal Club, DARE, and CCTR) (to the second quarter of 2005) databases for implant/screw loading during orthodontic treatment.

Eligibility of the articles identified by each search engine was determined by reading their respective title and abstract. Two researchers selected the articles to be collected. An interexaminer agreement of 0.880 (interexaminer kappa) was obtained. Any discrepancies were settled through discussion. All the articles that appeared to meet the inclusion criteria on the basis of their abstracts were selected and collected. Articles from abstracts in which not enough relevant information was stated were also obtained.

The final selection was independently completed by the researchers reading the complete articles, and their results were compared. An interexaminer agreement of 0.920 (interexaminer kappa) was obtained. Reference lists of the selected articles were hand-searched for additional relevant publications that may have been missed by the search engines.

RESULTS

The search results and the initial number of abstracts selected according to the selection criteria from the various databases are shown in Table 1. From the 21 studies initially selected to be eligible on the basis of their title and abstract, only 14 studies actually fulfilled the selection criteria after reading the complete article. After hand-searching the reference lists of the 21 studies, no other study appeared that had not been shown in the electronic search.

Of the 14 remaining articles, two[11,12] were rejected because they reported prosthetic use of implants. Another study[13] was rejected because treatment involved the usage of microplates (Table 2).

Finally, only 11 articles, which met all the inclusion criteria, remained. A methodological quality checklist was used to evaluate the selected articles, and the application of the methodological quality checklist is shown in Table 3. As shown in Table 4, all the selected articles received very low-quality scores and had definitive methodological failures.

The scoring process was based on a version previously used in a systematic review by Lagravere et al[14] No attempt was made to imply that this evaluation was validated. A summary of the sample size, type of appliances used, and protocols applied is shown in Table 5. A description of the manufacturer and appliance characteristics is shown in Table 6.

TABLE 4. Methodological Score of Initial Selected Articles[a]

Authors	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total No. of Checks	% of the Total
Bernhart et al[8]	√	√	X	X	X	√	X	X	X	X	X	√√	X	√	6	30
Cheng et al[4]	√	√	X	≠	X	√	X	X	X	X	X	√√	X	√√	7.5	37.5
Costa et al[17]	√	√	X	X	X	√	X	X	X	X	X	X	X	X	3	15
Freudenthaler et al[10]	√	X	≠	X	X	X	X	X	X	X	X	X	X	X	1.5	7.5
Gelgör et al[7]	√	√	√	X	X	√	X	√	X	X	X	X	X	√	6	30
Higuchi and Slack[6]	X	X	X	X	X	√	X	X	X	X	X	X	X	X	1	5
Liou et al[5]	X	X	X	X	X	√	X	√	X	X	X	√	X	√	4	20
Miyawaki et al[3]	√	X	X	√	X	X	X	X	X	X	X	√	X	√	4	20
Ödman et al[15]	X	X	X	X	X	√	X	√	X	X	X	X	X	X	2	10
Trisi and Rebaudi[2]	√	X	X	√	X	√	X	X	X	X	X	X	X	X	3	15
Wehrbein et al[16]	X	X	X	X	X	√	X	X	X	X	X	X	X	X	1	5

[a] A-N indicates methodological criteria in Lagravere et al[14]; √, satisfactorily fulfilled the methodological criteria (1 check point); ≠, partially fulfilled the methodological criteria (0.5 check point); and X, did not fulfill the methodological criteria (0 check point).

TABLE 5. Description of Selected Articles

Authors	Sample	Number and Type of Appliance
Bernhart et al[8]	21; 15 females, 6 males 25.8 ± 9.9 (12.7–48.1) y	21 mini-implants
Cheng et al[4]	44; 38 females, 6 males 29 ± 8.9 (13–55) y	92 mini-screws
Costa et al[17]	14	16 mini-screws
Freudenthaler et al[10]	8; 4 females, 4 males 22.1 (13–46) y	15 screws
Gelgör et al[7]	25; 18 females, 7 males 13.9 (11.3–16.5) y	Screws
Higuchi and Slack[6]	7; 5 females, 2 males 33.1; (22–41) y	14 implants
Liou et al[5]	16; 22–29 y	32 mini-screws
Miyawaki et al[3]	51; 42 females, 9 males 21.8 ± 7.8 y	134 screws
Ödman et al[15]	9; 6 females, 3 males 47 (17–64) y	23 implants
Trisi and Rebaudi[2]	41 patients	Ortho-implants
Wehrbein et al[16]	4; 2 females, 2 males (18–27) y	6 ortho-implants

Implants

From the final 11 selected articles, five[2,6,8,15,16] evaluated implant use for orthodontic purposes. All these studies used different types of implants in terms of length, diameter, and manufacturer (Table 6). Patient samples ranged from four[16] to 41 patients.[2]

All five studies presented a waiting period before loading the implants, with forces ranging from 80 to 550 g. Bernhart et al placed 21 mini-implants on the paramedian region of the palate for protraction of posterior teeth, distal movement of anterior teeth, unilateral mesial movement, and intrusion purposes. A waiting period of 4.2 months before loading the implants was used in this study. The amount of force applied after this period was not specified but presented an 86% success rate after 11.6 months of use (Table 5).

Higuchi and Slack placed 14 implants bilaterally in the third molar region of the mandible and in the first molar region when these teeth were extracted. After placement, a waiting period of 4 to 6 months was used after applying an initial force of 150–200 g and increasing it to 400 g. Although they did not specify the treatment procedures, they presented a success rate of 100% on a 36-month period of use.

Ödman et al[15] placed 21 implants; they did not specify the place of implant insertion but did specify their usage for tipping, torque, rotation, intrusion, extrusion, and tooth bodily movements. Their waiting period ranged from 3 to 9 months. Although they did not specify the forces used, after an average anchorage period of 17 months, they presented a success rate of 100%.

Trisi and Rebaudi[2] did not specify the quantity of ortho implants used but applied a waiting period of 2 to 12 months before loading the implants with forces of 80 to 120 g. Sites of insertion varied from the paramedian region of the hard palate to the alveolar bone of the maxillary retromolar and mandibular molar region when these teeth were extracted. Procedures followed were distalization of maxillary and mandibular molars, contemporaneous distalization of a group of teeth (molars and premolars), tipping, uprighting, intrusion, extrusion, and transfer of anchorage to other parts of the mouth. After an anchorage period that ranged from 2 to 15 months, a success rate of 100% was reported.

Finally, Wehrbein et al,[16] after placing six ortho implants on the paramedian region of the hard palate and the alveolar bone in the retromolar site, waited approximately 3 months before loading. In one case, an implant was loaded immediately. Forces applied varied from approximately 200 to 600 g for Class II malocclusion correction (retraction or protrusion of the anterior teeth and mesialization of premolars/molars). After an anchorage time of 8 to 20 months, they presented a 100% success rate.

Screws

From the final selected articles, six[3–5,7,10,17] evaluated screws (Table 6). The patient samples in these studies were diverse, ranging from eight patients in one study[10] to a maximum of 44 to 51 patients in two other studies.[3,4] When considering screw samples, the quantity varied from 15 screws in the Freudenthaler et al[10] study to 134 screws used by Miyawaki et al[3] (Table 5).

Four studies[3,7,10,17] applied orthodontic forces immediately after insertion of the screws. These forces varied between 150 g[10] and reaching a maximum of 500 g.[7] Freudenthaler et al[10] placed the screws at the level of the apical thirds of the premolar/canine roots, the anterior part of the molar extraction site, and between the second incisor and the canine roots to protract the posterior teeth in the lower jaw for a period of 11.3 months and presented a success rate of 93.4%. Gelgör et al[7] placed the screws for a period ranging between 3 and 6.2 months. These were placed 5 mm behind the incisive canal and 3 mm to the right or left of the raphe. The procedure followed was distal movement of molars, but they failed to re-

TABLE 5. Extended

Time Before Loading	Force Applied	Anchorage Time	Failure
4.2 mo		11.6 mo	3
2–4 wk	100–200 g		15
Immediately loaded			
Immediately loaded	150 g	11.3 mo	1
Immediately loaded	500 g	3–6.2 (4.6) mo	
4–6 mo	Initially 150–200 g/later 400 g	36 mo	0
2 wk	400 g	9 mo	
Immediately loaded	<200 g	12 mo	10
3–9 mo		4–33 (17) mo	0
2–12 mo	80–120 g	2–15 mo	0
1 (0), others (12 wk)	200–600 g	8–20 mo	0

TABLE 6. Description of Appliances Used in Selected Articles

Authors	Fixture Material	Manufacturer	Diameter of Fixture	Length of Fixture
Bernhart et al[8]	Commercially pure titanium	Brånemark Nobel Biocare, Sweden	3.75 mm	3 mm, 4 mm
Cheng et al[4]	Titanium	Leibinger, Freiburg, Germany or Mondeal, Tuttlingen, Germany	2 mm	5 mm, 15 mm
Costa et al[17]	Titanium	Cizeta	2 mm	9 mm
Freudenthaler et al[10]	Titanium	Leibinger, Freiburg, Germany	2 mm	13 mm
Gelgör et al[7]	Pure titanium with a sandblasted surface	IMF Stryker, Leibinger, Germany	1.8 mm	14 mm
Higuchi and Slack[6]	Titanium	Nobelpharma AB, Göteborg, Sweden		10 mm
Liou et al[5]		Leibinger, Tuttlingen, Germany	2 mm	17 mm
Miyawaki et al[3]	Titanium		1 mm-1.5 mm-2.3 mm	6 mm-11 mm-14 mm
Ödman et al[15]	Commercially pure titanium	Brånemark System®, Nobelpharma AB, Göteborg, Sweden		
Trisi and Rebaudi[2]	Commercially pure titanium Grade 3 with blasted surface	Exacta, Biaggini Ormco, Italy	4 mm-3.3 mm	11 mm, 13 mm-5 mm, 7 mm
Wehrbein et al[16]	Titanium with sandblasted and acid-etched surface (SLA)	Straumann Orthosystem, Waldenburg, Switzerland	3.3 mm	4 mm, 6 mm

port the success rate of the screws. The third study[3] placed the screws into the buccal alveolar bone through the attached gingiva between the second premolar and the second molar region of the maxilla or the mandible, the process applying a force of 200 g for a 12-month period. The success rate reported was approximately 86%.

Costa et al[17] placed screws on the maxilla (inferior surface of the anterior nasal spine, midpalatal suture, and infrazygomatic crest) and mandible (retromolar position, edentulous areas of the alveolar process, laterally in the molar and premolar region, and symphysis). These screws were used in the maxilla for proclination of the upper incisors, retraction and intrusion of overerupted incisors, and anchorage for intrusion of molars that overerupted secondarily to extraction of the occluding teeth, intrusion, and buccal tipping and in the mandible for mesial movement of the molars, uprighting, moving single teeth, intrusion, and proclination of mandibular incisors. In this study, they did not report anchorage time, forces applied, and success rate.

Two studies[4,5] presented a waiting period of at least 2 weeks before loading the screws. Liou et al[5] applied a force of 400 g on the screws placed at the zygomatic buttress of the maxilla to create a mass retraction of the anterior teeth for 9 months and did not report the success rate obtained. Cheng et al[4] placed the screws

on the mandibular and maxillary posterior zones to intrude and upright molars and to retract and protrude posterior teeth. After the 2- to 4-week waiting period, they applied forces ranging between 100 and 200 g, reporting a success rate of 89%.

DISCUSSION

Anchorage has been a concern among orthodontists and has created many problems in this field. This problem has arisen because appliances are in balance, meaning that two objects connected by active appliances are subject to equal and opposite forces. Intraoral and extraoral appliances have been used to fulfill the anchorage requirement, but because of side effects and compliance issues, new methods have been developed to obtain effective anchorage such as implants and screws.[17]

Although implants and screws do not present the side effects and compliance issues presented by other techniques, they have to be stable and capable of resisting forces that act on the teeth.[9] To obtain these characteristics, these appliances have to be used following a correct protocol, ie, when to apply the force after their insertion.

No previous systematic review or meta-analysis has been published regarding loading protocols for implants and screws for orthodontic use. Although there are many studies published on these appliances, the majority are case reports and technical descriptions.

After reviewing all published material on implants and screws in orthodontics, only 11 articles satisfied the inclusion criteria of human clinical trials and reporting results in orthodontic treatments. When the methodological checklist was applied to them, the selected articles obtained very low-quality scores and had definitive methodological failures. From the final 11 articles, five[2,6,8,15,16] evaluated implants use in orthodontics, and six[3–5,7,10,17] evaluated screw use in orthodontics.

When reviewing the implant studies, all presented a waiting period before loading for orthodontic reasons. These waiting periods varied from 2 months[2] to a maximum of 12 months,[2] presenting an average waiting time of 4 to 6 months.[2,6,8,15,16]

Although implants present a very rigid anchorage unit,[5] they present some disadvantages. Among these are that their placement is limited by their size and design to edentulous and retromolar areas,[5,7] laboratory work is required, they are difficult to remove (when necessary),[5,17] it is a traumatic surgical procedure,[4,6,7] and hygiene is difficult.[4,7] Another factor is its high cost[4,5,17] as well as presence of symptoms during the healing process.[7] This healing and osseointegration process is long (between 2 and 6 months),[2,5–7,16] sometimes reaching a period between 9[15] and 12 months.[2] Nevertheless, the implant success rate is 100%[2,6,15,16] in the majority of cases presented by the selected studies.

Regarding screws, four[3,7,10,17] studies applied forces immediately after insertion, whereas the other two[4,5] presented a waiting period of a minimum of 2 weeks.

Screws present some advantages when compared with implants. For example, they do not present major anatomical limitations for insertion, no surgery is necessary, and the cost is low.[3–5] Also, there are no symptoms after insertion,[3] no laboratory work is necessary, they are easy to remove,[5] and they only require a short waiting period before loading,[4,5] if any.[3,7,10,17] This last advantage reduces the treatment period and, thus, increases patient acceptability.[10]

The short waiting period for healing and osseointegration after screw insertion is because of mechanical retention that is initially obtained. This gives the screws a sufficient primary stability to resist orthodontic loading forces,[3,5] ranging between 30 and 250 g used in different orthodontic movements.[9] Nevertheless, this short waiting period is sufficient for healing but not for osseointegration, which is an important factor in maintaining a rigid anchorage unit. Histologically, it has been demonstrated that the premature load generates the formation of fibrous tissue between the bone and the screw. This layer of tissue gives the mechanical retention for the screw to not displace in the direction of the applied force.[5] In some cases, this layer of tissue can become granulation tissue because of the short time given for the formation of a correct osseointegration.[18]

Liou et al[5] demonstrated that the screws are clinically stable but not absolutely stationary when forces are loaded on them, which, in the case of implants, would be because of the correct osseointegration. Although there is some displacement by the screws, they have enough stability to complete the treatment. These screws mostly move toward the direction of the applied force, ranging from −1 to 1.5 mm displacement. For this reason, it is recommended that they should be placed 2 mm away from any vital anatomical structure (roots, nerves).

When compared with implants, the screws present many advantages over implants, but in the success rate, the implants presented on average higher success rates than did screws on the selected studies.

Concerning the forces applied to implants or screws, these should be proportional to the amount of osseointegration, which at the same time depends on the surface contact between material and osseous tissue.[9,19] Factors that are involved in this increase in surface are length, diameter, and shape of the appliance.[9] According to Favero et al,[9] there is an inverse relationship

between length and diameter where if the length decreases, the diameter should increase. In this regard, studies on screws establish that the length of the screws have no relationship with their stability,[3,4] whereas the diameter does.[3]

Success rates for implant and screw usage in orthodontics depend on many factors starting from the loading protocols to the dimensions and insertion sites of these appliances. Future research should involve randomized clinical trials to evaluate all these factors on implant and screw success rates in orthodontics and continued follow-up for possible relapse.

CONCLUSIONS

The following conclusions should be considered with caution because only a secondary level of evidence was found.

- Loading protocols for implants involve a waiting period of a minimum of 2 months before applying orthodontic forces.
- Loading protocols for screws involve immediate loading or a waiting period of 2 weeks to apply orthodontic forces.
- The success rates for implants were, on average, higher than for screws.

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