Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods (Review)

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[Intervention Review]

Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods

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ABSTRACT

Background

The term anchorage in orthodontic treatment refers to the control of unwanted tooth movement. This is conventionally provided either by anchor sites within the mouth, such as the teeth and the palate or from outside the mouth (headgear). Orthodontic implants which are surgically inserted to bone in the mouth are increasingly being used as an alternative form of anchorage reinforcement in orthodontics.

Objectives

The primary objective of this review was to evaluate the effectiveness of surgical methods for preventing unwanted tooth movement compared with conventional anchorage reinforcement techniques. The secondary objectives were to examine patient acceptance, discomfort and failure rates associated with these techniques.

Search methods

The Cochrane Oral Health Group's Trials Register, CENTRAL, MEDLINE and EMBASE were searched. No language restrictions were applied. Authors were identified and contacted to identify unpublished trials. The most recent search was conducted in February 2006.

Selection criteria

Randomised or quasi-randomised clinical trials involving the use of surgically assisted means of anchorage reinforcement on orthodontic patients. Inclusion and exclusion criteria were applied when considering the studies to be included in this review.

Data collection and analysis

Data extraction was performed by two review authors working independently using a previously piloted data collection form. Data were entered into RevMan with planned analysis of mean differences (MD) and 95% confidence intervals (CI) for continuous outcomes and risk ratios (RR) and 95% CI for dichotomous outcomes. Pooling of data and meta-analysis were not performed due to an insufficient number of similar studies.

Main results

At present few trials have been carried out in this field and there are little data of adequate quality in the literature to meet the objectives of the review. The review authors were only able to find one study assessing the use of surgical anchorage reinforcement systems.

This trial examined 51 patients with 'absolute anchorage' requirements treated in two centres. Patients were randomly allocated to receive either headgear or a mid-palatal osseointegrated implant. Anchorage loss was measured cephalometrically by mesial movement of dental and skeletal reference points between T1 (treatment start) and T2 (end of anchorage reinforcement). All skeletal and dental points moved mesially more in the headgear group than the implant group. Results showed significant differences for mesial movement of the maxillary molar in both groups. The mean change in the implant group was 1.5 mm (standard deviation (SD) 2.6; 95% CI 0.4 to 2.7) and for the headgear group 3.0 mm (SD 3.4; 95% CI 1.6 to 4.5). The trial was designed to test a clinically significant difference of 2 mm, so the result was not statistically significant, but the authors conclude that mid-palatal implants do effectively reinforce anchorage and are an acceptable alternative to headgear in absolute anchorage cases.

Authors' conclusions

There is limited evidence that osseointegrated palatal implants are an acceptable means of reinforcing anchorage. The review authors were unable to identify trials addressing the secondary objectives of the review relating to patient acceptance, discomfort and failure rates. In view of the fact that this is a dynamic area of orthodontic practice we feel there is a need for high quality, randomised controlled trials. There are financial restrictions in running trials of this nature. However it would be in the interest of implant manufacturers to fund high quality, independently conducted, trials of their products.

PLAIN LANGUAGE SUMMARY

Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods

Anchorage is the resistance to unwanted tooth movement during orthodontic treatment. Control of anchorage is important in treatment planning and often dictates treatment objectives. It has been suggested that more effective anchorage reinforcement may be offered by surgically placed temporary anchorage devices.

There is little evidence to support the use of surgical anchorage systems over conventional means of orthodontic anchorage reinforcement. However there is evidence from one recent trial that showed mid-palatal implants are an acceptable alternative to conventional techniques for reinforcing anchorage.

The review authors were able to find only limited evidence on the use of surgical means of preventing anchorage loss compared with conventional techniques and the data showed equivalence, but not superiority of either type.

BACKGROUND

Orthodontic brace treatment is used to straighten teeth that are crooked or that stick out. There is some evidence that this makes them easier to clean and may have a positive psychological benefit for children (O'Brien 2003).

To straighten a tooth it is necessary to apply a force for it to move. This force will have an equal and opposite reaction force, which will act upon teeth that the orthodontist might not want to move. In most cases it is necessary to control these reaction forces to stop unwanted tooth movement, which will prevent the teeth being fully straightened. Resistance to the reaction forces is provided from anchor sites and is known as anchorage.

Traditionally anchorage may be provided from anchor sites within the mouth (intraoral anchorage) or from outside the mouth (extraoral anchorage). Intraoral anchor sites include teeth or other oral structures. Extraoral anchorage may be achieved with headgear, using the back of the head or the neck.

Intraoral anchorage can be supplemented by securing teeth together by means of metal wires, such as transpalatal arches or lingual arches. Anchorage may also be supplemented by using elas-

tic traction to the opposing arch. This is termed intermaxillary anchorage (Mitchell 2002). However, the intraoral ways of reinforcing anchorage can never completely prevent movement of the anchorage teeth, a condition known as absolute anchorage.

Greater anchorage can be obtained with extraoral anchorage. However there are concerns about patient compliance with headgear (Cureton 1993) and also issues over patient safety. Samuels has described a range of soft tissue and eye injuries associated with headgear. In a small number of cases this has resulted in the loss of an eye (Booth-Mason 1988; Samuels 1994; Samuels 1996).

Several means of reinforcing anchorage using surgical techniques have been proposed. Gainsforth and Higley suggested the use of metallic screws as anchors as long ago as 1945 (Gainsforth 1945). Melsen in 1998 experimented with anchorage from wires passed through the zygomatic arch in cases where posterior teeth were absent or of poor quality (Melsen 1998).

Dental implants are structures placed surgically into the jaws where they may become attached or osseointegrated with the bone. Introduced in the 1960s (Adell 1981) osseointegrated implants have been used extensively in restorative and surgical dentistry principally to replace missing teeth. However, it was not until 1997 that the use of non-osseointegrated, titanium microscrew implants to reinforce orthodontic anchorage was proposed (Kanomi 1997). The introduction of surgically reinforced anchorage is important for orthodontics as it may offer the possibility of circumventing many of the shortcomings of traditional anchorage methods.

OBJECTIVES

The primary objective of the review was to evaluate the effectiveness of surgically assisted techniques in the prevention of unwanted tooth movement during orthodontic treatment compared with conventional techniques.

The secondary objective was to examine patient acceptance, failure rates and discomfort during orthodontic treatment with surgical reinforcement of anchorage.

Null hypotheses

There is no difference in the reinforcement of anchorage provided by surgically assisted techniques compared to that provided by conventional means during orthodontic treatment.
There is no difference in the patient acceptance, failure rates and discomfort provided by surgically assisted techniques compared to that provided by conventional means during orthodontic treatment.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised or quasi-randomised controlled clinical trials in which surgically assisted anchorage reinforcement techniques during orthodontic treatment were studied.

Types of participants

Patients of any age undergoing orthodontic treatment with braces.

Types of interventions

Mid-palatal implants, onplants, miniscrews, spider screws, titanium plates and zygomatic wires were considered under the term surgically assisted means of reinforcing anchorage.
The control group could have included patients with anchorage supported by conventional means including headgear, chincaps, facemasks, transpalatal arches (including Nance buttons), lingual arches and interarch elastics.
Studies comparing two methods of surgically assisted anchorage could also have been included.

Types of outcome measures

The primary outcome measure was the difference between groups in the movement of teeth used for anchorage purposes. Anchorage loss was measured in dental terms by residual overjet at the end of treatment and also mesial movement of the upper first permanent molar teeth, as measured on a lateral cephalometric radiograph. Outcomes assessing the patient perceptions of pain, acceptability, treatment time, compliance, incomplete treatment, such as failure to finish or economic factors would have been included if found.

Search methods for identification of studies

All relevant studies irrespective of language were searched.

Electronic searching

Relevant studies were identified by searching the following electronic databases:
Cochrane Oral Health Group Trials Register (searched 1 February 2006)
Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2006, Issue 1)
MEDLINE (1966 to 31 January 2006)
EMBASE (1980 to 1 February 2006).
To identify studies considered for this review, detailed search strategies were developed for each database searched. These were based

on the search strategy developed for MEDLINE but revised appropriately for each database (Appendix 1). The search strategy used a combination of controlled vocabulary and free text terms and was combined with all three phases of the Cochrane Sensitive Search Strategy for Randomised Controlled Trials (RCTs) as published in the *Cochrane Handbook for Systematic Reviews of Interventions* 4.2.6.

Handsearching

The journals considered important to this review were:
American Journal of Orthodontics and Dentofacial Orthopedics
Angle Orthodontist
European Journal of Orthodontics
Journal of Orthodontics (formerly British Journal of Orthodontics)
Orthodontics and Craniofacial Research (1998 to 2001 Clinical Orthodontics and Research)
Journal of Dental Research
Journal of Dentistry
Journal of Clinical Orthodontics
Clinical Oral Implant Research/Orthodontics and Craniofacial Research
International Journal of Oral and Maxillofacial Implants
Clinical Implant Dentistry
Related Research and Implant Dentistry.
Handsearching of journals was performed if this had not already been carried out as part of the Cochrane handsearching programme.

Reference searching

References of identified trials were checked for more relevant studies.

Personal contact

Letters were sent to the author(s) of related studies published during the last decade to obtain information about other unpublished studies that might be eligible for inclusion. Authors were also contacted for further information to clarify their reports.

Unpublished studies

In addition to contacting authors, unpublished studies were sought by searching abstracts and conference proceedings. Manufacturers of implant products used in orthodontics were approached for information concerning unpublished or ongoing studies.

Data collection and analysis

Study selection

The title, keywords and abstract of reports identified from electronic searching were examined independently by two review authors (Richard Skeggs (RS) and Philip Benson (PEB)) for evidence of these criteria.
(1) It was a randomised or quasi-randomised clinical trial.
(2) It involved the use of a surgically assisted means of reinforcing anchorage during orthodontic treatment.
If the report fulfilled these criteria or if the review authors were unable to assess this from the title, keywords or abstract then the full article was obtained.

Data extraction

Data extraction was performed using a data collection form. This was done by two review authors independently and in duplicate. Disagreements were resolved where required by discussion or by the involvement of a third review author. Data collected included:

- Number and age of subjects
- Types of intervention (anchorage reinforcement used and which teeth were banded)
- Mean duration of the study
- Outcome measures (anchorage loss, pain, compliance, acceptability and failure rate).

Methodological review of clinical trials

Methodological quality was assessed independently and in duplicate by two review authors (RS and PEB). Any disagreements were resolved by discussion or further independent assessment by a third review author (Fiona Dyer (FD)). Agreement was assessed using a Kappa statistic. The following were included in the review of methodology according to the criteria described in the *Cochrane Handbook for Systematic Reviews of Interventions* 4.2.6.
Four main quality criteria were examined.
(1) Method of randomisation, recorded as:
(A) Yes - adequate, as described either in the text or after contacting the author
(B) No - inadequate, as described in the text or after contacting the author
(C) Unclear - unclear in the text and unable to contact the author.
(2) Allocation concealment, recorded as:
(A) Yes - adequate, as described either in the text or after contacting the author
(B) No - inadequate, as described in the text or after contacting the author
(C) Unclear - unclear in the text and unable to contact the author.
(3) Outcomes assessors blinded to intervention, recorded as:
(A) Yes - adequate, as described either in the text or after contacting the author
(B) No - inadequate, as described in the text or after contacting the author
(C) Unclear - unclear in the text and unable to contact the author.

(4) Completeness of follow up (was there a clear explanation of withdrawals and drop outs in each treatment group) assessed as:
(A) Yes - numbers in the methods and results were the same and drop outs were explained
(B) No - numbers in the methods and results were not the same and drop outs were not explained
(C) None - no drop outs or withdrawals, as shown by the same number of participants in the methods and results.
A study was assessed to have a high risk of bias if it did not record a 'Yes' in three or more of the four main categories, moderate risk if two out of the four categories did not record a 'Yes' and low risk if randomisation, assessor blinding and completeness of follow up were considered adequate.
Other methodological criteria examined were.

- Sample size calculation reported.
- Comparability of groups at the start.
- Clear inclusion/exclusion criteria.
- Validity and reproducibility of the method of assessment.

Data synthesis

It was planned that pooling of data and meta-analysis were to be carried out in the event of sufficient similarities between studies in the types of participants, interventions and outcomes. A weighted treatment effect would be calculated and the results expressed as mean differences (MD) and 95% confidence intervals (CI) for continuous outcomes and risk ratios (RR) and 95% CI for dichotomous outcomes. If there were intraindividual (split-mouth) and parallel group studies to be combined in the review for the continuous or dichotomous outcome variables this would be conducted using STATA 7; other analyses would be conducted in RevMan where possible. Variance imputation methods would be used to estimate appropriate variance estimates in split-mouth studies, where the appropriate standard deviation of the differences are not included in study reports (Follmann 1992). The significance of discrepancies in the estimates of the treatment effects from the different trials were to be assessed by means of Cochran's test for heterogeneity. However there were insufficient trials to permit this.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.
Summary details are given in the Characteristics of included studies and Characteristics of excluded studies tables.

The initial search strategy run in November 2004 identified 157 citations of which 147 were rejected after examination of the title and abstract.
Ten studies were selected for more detailed evaluation of the full publication. None fulfilled the criteria for inclusion.
A further literature search conducted in January/February 2006 identified no further studies appropriate for inclusion.
One trial (Benson) was conducted whilst this review was prepared and was identified from personal contact with the authors. This trial was appropriate for inclusion. The results of this trial have been accepted for future publication. This study compared mid-palatal implants versus headgear in a group of patients with Class II Division 1 malocclusions deemed to have an 'absolute anchorage' requirement.

Risk of bias in included studies

The studies in this field were generally of low quality. Allocation concealment, blinding and information on withdrawals were assessed by the review authors for all papers. There was complete agreement for allocation concealment and blinding (Kappa = 1).
Only one study (Benson) in which participants were randomly allocated to one of two groups for comparison was found. The methodological quality of this study was independently assessed by Richard Skeggs and Fiona Dyer and was rated 'A' in all four main quality criteria.

Effects of interventions

One study was accepted as appropriate to this review (Benson). This trial examined 51 patients with 'absolute anchorage' requirements treated in two centres. Patients were randomly allocated to receive either headgear or a mid-palatal osseointegrated implant. Three participants (one in the headgear group and two in the implant group) decided not to go ahead with treatment after they had been allocated to groups. One participant in the headgear group was excluded from the analysis because no T2 (end of anchorage reinforcement) cephalometry was taken. Treatment times were 2.23 years (standard deviation (SD) 0.62) in the headgear group and 2.15 years (SD 0.59) in the implant group.
Anchorage loss was measured cephalometrically by mesial movement of dental and skeletal reference points between T1 (treatment start) and T2 (end of anchorage reinforcement). All skeletal and dental points moved mesially more in the headgear group than the implant group. Results showed significant differences for mesial movement of the maxillary molar in both groups. The mean change in the implant group was 1.5 mm (SD 2.6; 95% confidence interval (CI) 0.4 to 2.7) and for the headgear group 3.0 mm (SD 3.4; 95% CI 1.6 to 4.5). The mean difference between groups was -1.50 (95% CI -3.23 to 0.23). The trial was designed to test a clinically significant difference of 2 mm, so the result was not

statistically significant, but the authors conclude that mid-palatal implants do effectively reinforce anchorage and are an acceptable alternative to headgear in absolute anchorage cases.
This trial did not report data on patient acceptance, failure rates or patient discomfort.

Those studies that were identified and excluded are outlined in the Characteristics of excluded studies table.

DISCUSSION

The objective of this systematic review was to evaluate the effectiveness of surgical techniques to prevent unwanted tooth movement compared with conventional anchorage reinforcement techniques, however due to a shortage of high quality studies we are able to make only limited conclusions regarding the effectiveness of these techniques. This discussion will therefore address areas highlighted by the wider literature that require further investigation in order to determine whether surgical orthodontic anchorage is successful.

This is a period of innovation and experimentation in the field of surgical orthodontic anchorage and new devices are being introduced on a frequent basis. It is important to distinguish between the different types of surgical anchorage devices available, as they are not a single entity. Differences between implants include the material they are made of, size, site of anchorage and the necessity for complete bony healing or osseointegration. One example of how techniques have changed with time is the palatal onplant, which was designed to rest on the bone under the palatal mucosa, rather than being placed within the bone (Block 1995). This was initially considered an innovative means of addressing the problem of anchorage reinforcement in the upper jaw. However, early reports of failures (Celenza 2000) and the lack of recent interest would suggest this approach is largely historical.

Early work on surgical anchorage reinforcement was carried out with implants which osseointegrate or heal with the bone. This followed Brånemark's reports of their successful use when replacing teeth that had been previously lost (Branemark 1977). The first implant fixtures were relatively large diameter (3 to 4 mm) pre-prosthetic implants made of titanium, which were placed using established and tested surgical techniques. Research in animal models and later human subjects showed that successful bone healing and remodelling could be maintained when the implant was subjected to the continuous and low magnitude forces applied during orthodontic treatment (Wehrbein 1997; Wehrbein 1998). It was reasonable to assume that these fixtures would provide rigid skeletal fixation and hence may be used to supplement orthodontic anchorage in cases, which would be difficult or even impossible to treat with conventional techniques.

One limitation with the implants which osseointegrate is the site in which they may be placed. It is unusual for space to be available in an orthodontic patient to allow a conventional implant to be positioned in the alveolar ridge unless this is to be used later to replace teeth that are missing. Other sites are required and the common areas for this type of implant are in the lower jaw behind the teeth or in the hard palate of the upper jaw. Surgery in the retromolar area can be complicated by limited access and can lead to damage to the nerve involved in transmitting sensations from the mouth and lower part of the face.

In the palate complications include the reduced height of bone available, which means that shorter implants have to be used. Bone turnover rates are less at this site than for alveolar bone, therefore healing might be prolonged and in pre-adolescent patients there is the possibility of damage to the midline suture, which is an important area of growth in the upper jaw (Bernhart 2001). There have also been reported technical difficulties with attachments to palatal implants failing or distorting (Tinsley 2004; Wehrbein 1999; Wehrbein 2004). Although quoted success rates for palatal implants are relatively high (Wehrbein 1999), the sample sizes reported to date have been small.

More recently attention has turned to the use of titanium plates and screws originally designed to splint broken jaws. These are likely to become increasingly popular, as they are more versatile in terms of anchorage site. They also offer the possibility of simpler surgery and minimal anatomical risks to placement. The screws in particular, rely on mechanical retention for their fixation rather than osseointegration. A force can be applied to move the teeth immediately after the implant has been placed, instead of waiting for bony healing. Potentially reduced cost and patient discomfort are additional advantages to the orthodontist. Several anchorage screw systems are now available and have been shown to be effective in case studies.

A number of research questions need to be addressed for these newer anchorage systems. For example, what implant material can be used if bony healing is not necessary? It is possible that medical grade titanium, which has excellent biocompatibility but tends to be weak in thin section, is not the ideal material for small orthodontic anchors. Other metals may allow sufficient host compatibility, but are less fracture resistant. This ensures that implants can be made smaller, allowing more options for placement. Screw length is another important factor to be considered in further trials. Clinicians should be aware of the depth of soft tissue at the placement site to ensure enough implant is placed in the bone. Most studies record the screw length, rather than length in bone.

Loading of implants is probably an important factor in success that has yet to be fully explored. Important questions include when and how much force should be applied to the implant. Originally Brånemark suggested a 4- to 6-month healing period for integrating implants to avoid micromotion and fibrous healing around

the implant. This was suggested on the basis that healing occurred in 6 weeks with a rabbit model. Bone turnover in humans is about three times slower and therefore an 18-week equivalent was used in humans with high success rates. Conventional implants have however been shown to successfully integrate with much shorter loading times (Esposito 2007). For mechanically retained fixtures, such as microscrews it is not necessary to wait for bony healing to occur, but it might still be beneficial to wait until after the initial inflammatory response to surgical trauma has subsided.

The amount and type of orthodontic force applied to the implant is an important consideration. Excessive force is likely to cause bony microfractures and mobility (Bernhart 2001), which will lead to the implant failing. There is weak evidence that light forces do not directly influence failure rates (Cheng 2004) and there is some evidence that applying a force to an implant is beneficial for bone remodelling rates and considerably accelerated implant stability (Odman 1994; Ohmae 2001). It has also been shown that an implant loaded with a constant force, similar to that applied in orthodontics, showed dense cortical lamellar bone, which is good for implant stability, whereas if the force was constantly changing (for example during chewing) there was evidence of crater shaped marginal bone defects and resorption, which might lead to early implant failure (Duyck 2001; Melsen 2000). It is unclear whether direction of pull will affect success, although it would seem sensible to avoid situations where the force pulls out the implant. The evidence would suggest it is reasonable to load these devices immediately, but there remains a need to assess this topic in greater detail in human subjects.

Another important outcome which requires further research is patient acceptability. There are a number of reports and case studies that have demonstrated good patient acceptance with all these devices and little or no need for pain control measures after placement and removal. However much of the work is anecdotal and little empirical data are available.

The literature suggests that various means of surgical anchorage reinforcement can be used as successful adjuncts to orthodontic treatment, but at present this field of research is in its infancy. There is a tendency for researchers and manufacturers to emphasise the merits of their own particular fixture of interest and currently case studies are the most prevalent reports. It is essential that properly controlled clinical trials are carried out to investigate all the factors outlined above to determine the most successful approach to the surgical management of orthodontic anchorage.

AUTHORS' CONCLUSIONS

Implications for practice

The use of different surgical reinforced anchorage systems based on osseointegrated fixtures or bone plates and screws is becoming increasingly common. It seems feasible that implant reinforced anchorage can assist the orthodontist to treat cases that would be difficult or even impossible to treat using conventional techniques. However we were able to identify little evidence to show that this is the case. There is evidence that mid-palatal implants are an acceptable alternative to headgear reinforced anchorage in orthodontic patients. However, at present there are insufficient research data on which to base much of our clinical practice.

Implications for research

Future research in this field should compare surgical anchorage systems against conventional anchorage reinforcement and also compare different types of surgical anchorage reinforcement. Areas for research include determining the best size and shape of the implant, as well as the type of material to use. Other areas of comparison are immediate versus delayed and static versus dynamic loading. It is also important to assess patient acceptability. Appropriate outcomes from such research should include anchorage loss, failure rates, financial costs and assessment of discomfort and related quality of life issues.

These studies would ideally demonstrate the following features:

-appropriate generation of randomisation and adequate allocation concealment - blinding where appropriate;

-reporting and analysis of withdrawals and drop outs;

-sample size calculations.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Benson

Methods	RCT conducted in a UK teaching hospital and a district general hospital. Patients randomly allocated to 1 of 2 parallel groups.
Participants	51 patients; results given for 47: 3 participants (2 in implant group and 1 in headgear group) decided not to go ahead with treatment after they had been allocated to groups. 1 in the headgear group was excluded from the analysis because no T2 (end of anchorage reinforcement) cephalometry was taken. Age 12-39. Class II Division 1 malocclusions with 'absolute anchorage' requirements
Interventions	Headgear versus mid-palatal implant. Treatment times: 2.23 years (SD 0.62) headgear group; 2.15 years (SD 0.59) mid-palatal implant group
Outcomes	Assessment of anchorage loss by radiographic measurement of mesial movement of molar and incisal reference points between T1 (treatment start) and T2 (end of anchorage reinforcement)
Notes	Data extraction and quality assessment by Richard Skeggs and Fiona Dyer

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

RCT = randomised controlled trial
SD = standard deviation

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Bernhart 2001	Not an RCT. No appropriate control group. Vague inclusion and exclusion criteria.
Cheng 2004	Not an RCT. Randomisation technique not described. No appropriate control group. No clear inclusion and exclusion criteria. Author contacted for further details but no reply.

(*Continued*)

Favero 2002	Literature review. There is no clear question, no description of searches or methodology. No evidence of a systematic protocol.
Freudenthaler 2001	Not an RCT. No appropriate control group. Some inclusion but no exclusion criteria.
Higuchi 1991	Prospective observational study. Not an RCT. No appropriate control.
Odman 1994	Not an RCT. Study aims not clear. No control group. Some inclusion but no exclusion criteria.
Roberts 1996	Case series. No control group. Aims not clear. No inclusion or exclusion criteria.
Sugawara 2002	Case series. Probably retrospective. Authors contacted for information but no reply. Study aim not clear. No inclusion or exclusion criteria.
Trisi 2002	Not an RCT.
Wehrbein 1999	Prospective observational study. No appropriate control group.

RCT = randomised controlled trial

DATA AND ANALYSES

Comparison 1. Anchorage loss

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mesial movement of the upper first permanent molar (radiograph)	1	47	Mean Difference (IV, Fixed, 95% CI)	-1.5 [-3.23, 0.23]

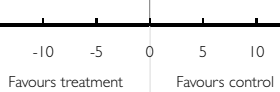
Analysis 1.1. Comparison 1 Anchorage loss, Outcome 1 Mesial movement of the upper first permanent molar (radiograph).

Review: Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods

Comparison: 1 Anchorage loss

Outcome: 1 Mesial movement of the upper first permanent molar (radiograph)

Study or subgroup	Mid-palatal implant N	Mean(SD)	Headgear N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Benson	23	1.5 (2.6)	24	3 (3.4)		100.0 %	-1.50 [-3.23, 0.23]
Total (95% CI)	**23**		**24**			**100.0 %**	**-1.50 [-3.23, 0.23]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.70 (P = 0.089)							
Test for subgroup differences: Not applicable							



APPENDICES

Appendix 1. MEDLINE search strategy

#1 exp ORTHODONTICS/ ME
#2 orthodontic$.mp.
#3 OR/1-2
#4 exp Dental Implants/
#5 exp Dental Implantation/
#6 ((Dental adj4 implant$) or (oral adj4 implant$) or (titanium adj4 implant$) or (palatal adj4 implant$) or (endosseous adj4 implant$).mp. [mp=title, abstract,name of substance, mesh subject heading]
#7 osseointegration.mp[mp=title, abstract,name of substance, mesh subject heading]
#8 titanium plate$.mp [mp=title, abstract,name of substance, mesh subject heading]
#9 zygoma$ wire$.mp [mp=title, abstract,name of substance, mesh subject heading]
#10 (miniscrew$ or miniscrew$ or microscrew$ or spiderscrew$).[mp=title, abstract,name of substance, mesh subject heading]
#11 (surgical$ or surgery).mp. [mp=title, abstract,name of substance, mesh subject heading]
#12 onplant$.mp. [mp=title, abstract,name of substance, mesh subject heading]
#13 OR/4-12
#14 anchor$.mp. [mp=title, abstract,name of substance, mesh subject heading]
#15 3 AND 13 AND 14

WHAT'S NEW

Last assessed as up-to-date: 15 May 2007.

Date	Event	Description
30 July 2008	Amended	Converted to new review format.

HISTORY

Protocol first published: Issue 1, 2005

Review first published: Issue 3, 2007

CONTRIBUTIONS OF AUTHORS

This review was jointly conceived and designed by Richard Skeggs and Philip Benson.

Richard Skeggs is the guarantor of the review and was responsible for undertaking searches and collecting data.

All review authors appraised papers, extracted data and were responsible for writing the review.

DECLARATIONS OF INTEREST

Philip Benson is among the authors of the included study, however, he was not involved in the quality assessment of this trial.

SOURCES OF SUPPORT

Internal sources

- School of Clinical Dentistry & Clifford Dental Hospital, University of Sheffield, UK.

External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

*Dental Implantation, Endosseous; *Tooth Movement; Extraoral Traction Appliances; Orthodontic Anchorage Procedures [*methods]; Randomized Controlled Trials as Topic

MeSH check words

Humans