NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of mini / micro screw implantation for orthodontic anchorage

Patients may require orthodontic treatment to realign teeth. Small screws can be inserted into the jaw bone to create points of anchorage against which a variety of connecting prostheses used to realign teeth can be applied.

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in March 2007.

Procedure name

- Mini / micro anchorage screw implantation for orthodontic anchorage

Specialty societies

- Association of Dental Implantology UK
- British Orthodontic Society
- British Association of Oral and Maxillofacial Surgeons

Description

Indications

Orthodontic procedures requiring a fixed anchorage point
Some orthodontic procedures require a fixed anchorage point to which a force can be applied in order to move teeth that are malpositioned, misaligned or impacted. The teeth that require treatment may be located in the upper or

lower jaw, and the treatment may require a force to be applied in any direction, and over a range of time periods.

Current treatment and alternatives

Many methods have been designed to provide anchorage points for orthodontic treatment. The choice of method depends on the site of the anchorage and the direction of force required. Usually, anchorage is achieved by use of other teeth, although the forces of orthodontic treatment may cause unintended, iatrogenic movement in these teeth. Alternative surgical procedures that can be used to provide anchorage points include osseointegrated dental implants, although a healing period is required before orthodontic force can be applied. External head gear may also be employed as anchorage; however, the aesthetic and psychological impact for the patient is undesirable.

What the procedure involves

Orthodontic mini- and microscrew systems have been developed from maxillofacial fixation techniques; they use mechanical retention for anchorage where additional anchorage is required over and above that which can eb gained from existing teeth. They are small (typically 1–2 mm in diameter and 8–15 mm in length) self-tapping titanium screws consisting of a body that connects to the bone, a neck that protrudes through the gum mucosa and a head suitable for connection to orthodontic loading systems. There is no universally agreed definition in terms of screw dimensions, and typology varies.

Under local anaesthesia a pilot hole is drilled into the maxilla or mandible and the screw is inserted through the bone cortex and into the alveolar bone using a screwdriver-like tool. For some microscrews a mucoperiostal flap needs to be created in the gum to aid insertion. More than one screw can be inserted if necessary. Orthodontic loading can be achieved immediately after insertion, although it is often undertaken at a second visit.

Following completion of the orthodontic treatment the screw(s) can be extracted (often without anaesthesia) and the incision site can be expected to heal spontaneously.

Efficacy

The Specialist Advisers considered the key efficacy outcomes of this procedure to be effective anchorage and intended tooth movement, failure rates, patient acceptance, reduction in extraction rate and requirement for external headgear.

Operative characteristics
Two case series reported on operative time for screw insertion. Procedure time ranged from 5 to 8 minutes in one series[1] and from 10 to 15 minutes in the other.[2]

Across four case series screw implantation was reported to be successful (usually defined by stable anchorage for 1 year or until completion of orthodontic treatment) in 0 to 85%[3], 85%[2], 81 to 89%[4], and 92% (208/227)[5] of screws (absolute figures presented where available). Success rates varied with the type of screw used. One case series of 87 patients fitted with 227 screws and followed up for 15 months reported that there was no statistically significant difference in success rates for four different screw types ($p = 0.154$; success rates were 80–94%).[5] This series also found that the success rate was significantly higher for screws inserted into the maxilla (96%; 119/124) compared with the mandible (86%; 89/103) ($p = 0.01$).[5] One case series reported that the overall success rate (defined as anchorage stability with no morbidity) was 84% (118/140)[7].

One case series reported that implant success rate was lower in patients with tissue inflammation at the site of implantation (54%) than among patients without inflammation (87%).[3]

One case series reported that the rate of screw loss at one institution decreased significantly from 23% (31/133) in the first patients treated to 5% (5/106) in subsequent patients once parameters for selection of screw size and location of insertion had been refined ($p < 0.001$).[6]

The screws were removed after orthodontic treatment (in some instances without anaesthesia). One case series reported that primary wound healing was achieved in all 25 patients at 14 months' follow-up.[1]

Safety

The Specialist Advisers highlighted the following important safety outcomes by which to evaluate this procedure: failure rates / need for replacement screws, adverse reactions, damage to adjacent teeth.

Across the case series, the rate of screw failure (breakage) ranged from 3% (2/59)[2] to 4% (8/227)[5].

One case series of 85 patients (239 screws inserted) reported that no patients had bleeding, abscess formation or tooth injury.[6]

Two case series reported that there were no contacts with tooth roots during the procedure in 175 screw insertions in 87 patients.[2,4]

In one case series, half of the 40 patients fitted with one type of screw did not require pain medication at any time after surgery.[4] In a second series, 60% of patients (6/10) in whom a mucoperiostal flap was created for screw insertion had pain (level of pain not described).[3]

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to mini / micro anchorage screw insertion. Searches were conducted via the following databases, covering the period from their commencement to 7 March 2007: Medline, PreMedline, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches. (See Appendix C for details of search strategy.)

The following selection criteria (Table 1) were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising methodology.
Patient	Patients with an indication for orthodontic treatment
Intervention/test	Mini / micro anchorage screw insertion
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on seven case series.[1–7]

Other studies considered relevant to the procedure but not included in the main extraction table (Table 2) are listed in Appendix A.

Existing reviews on this procedure

No published systematic reviews with meta-analysis or evidence-based guidelines were identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B details the recommendations made in each piece of guidance listed below.

Interventional procedures

None

Technology appraisals
None

Clinical guidelines
None

Public health
None

Table 2 Summary of key efficacy and safety findings on mini / microscrew implantation for orthodontic anchorage

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Luzi C (2007)[7] **Case series** Denmark Study period: Jan 2001 to Dec 2005 **n = 98 (140 screws)** Population: Male = 39%, Age = 34 years Indications: Patients receiving a mini screw implant as orthodontic anchorage for a range of dental movements, with insufficient teeth for anchorage, patients where force would generate adverse effects, asymmetrical force required. Technique: A total of 140 screws were placed in the 98 patients. Aarhus Mini-implants 1.5 to 2 mm diameter and 9.6 to 11.6 mm length were inserted under local anaesthesia, without a mucosal flap. Springs were used for loading immediately after insertion, load force is not described. **Follow-up: up to 37 months (mean or median not stated)** Conflict of Interest: Not stated	**Anchorage success** Success was defined as anchorage for 120 days or until end of orthodontic procedure. Failure was classified as either partial failure (clinical morbidity but stable anchorage, or failure (screw lost) The overall success rate (by screws) was 84% (118/140). Total failure rate by location of screw placement Site — Failure rate (by screw) Maxillary alveolar process — 9% (3/32) Mandibular alveolar process — 7% (5/72) Symphysis — 12% (2/17) Palate — 22% (2/9) Retromolar area — 10% (1/10) The partial failure rate by screw was 6% (9/140). It occurred sue to either inflammation of the soft tissue around the screw head, or increased turnover of the bone due to resorption of a deciduous tooth / tooth movement approximating the screw.	**No safety outcomes were reported.**	Operator experience not stated. Authors state that the number of failures was gradually reduced when a certain experience was obtained. Case selection and accrual method not stated Only the longest period of follow up (in one patient) is stated.

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Park H-S (2006)[5] **Case series** South Korea Study period: Not stated **n = 87 (227 screws)** Population: male = 40%; age = 15.5 years Indications: Patients receiving mini microscrew implant as orthodontic anchorage (not further defined). Technique: Type A: Stryker Leibinger microscrews n = 19 Type B:Osteomed microscrews n = 157 Type C: Absoanchor microscrews n = 46 Type D: KLS-Martin miniscrews n = 5 Screws were inserted under local anaesthesia, via a small (3–4 mm) vertical incision, a pit created with a round burr and a drilled pilot hole. Screws were placed in the maxillary arch or mandibular posterior area as necessary, at angles to minimise contact with tooth roots. Four different methods of force loading were used with < 200 g force applied. **Follow-up: 15 months (from insertion)** Conflict of interest: Not stated	**Anchorage success** The overall success rate was 92% of screws (208/227), with a mean period of force application of 15 months. Definition of success rate not stated. The success rates for each implant type were as follows: type A: 85%, type B; 94%; type C: 89%, type D: 80%. There was no significant difference between success rates for different screw types (p = 0.154) There were no significant differences according to patient age or sex. ***Success rate by location of screw placement*** **Site** / **Maxilla** / **Mandible** / **p value** Success rate / 96% (119/124) / 86% (89/103) / 0.01 **Site** / **Right** / **Left** / **p value** Success rate / 86% (101/117) / 97% (107/110) / 0.03 There was no significant correlation between success rate and the method of force application used for orthodontic treatment. **Factors affecting screw failure** The odds ratio of mobile screws at 5–8 months check up failing during anchorage period compared to those with no mobility was 0.041 (95% CI 0.008 to 0.207) (p < 0.001)	**Complications** **Outcome** / **Rate** Broken screw / 4% (8/227 screws) Broken during placement / 1% (3/227) Broken during removal / 2% (5/227) 7/8 screws that fractured were type B screws (the commonest type of screw used)	Retrospective case series The authors stated that undesired mobility may be increased if heavy forces are applied to the screw implants; implants can also fail if they are not sufficiently osseointegrated. The authors speculate that the higher success rate on the left-hand side of the mouth compared with the right may reflect better oral hygiene on that side by predominantly right-handed patients, which could reduce inflammation around the screw implants. When implants failed, new ones were placed in a similar area **It is not clear whether the study was powered to detect a difference in success rate between screw types.** One surgeon undertook all insertions.

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Berens A (2006)[6] **Case series** Germany Study period: Not stated **n = 85 (239 screws)** Population: male = 28%; mean age = 28 years Indications: Patients receiving mini or microscrew implant as orthodontic anchorage, usually for gap closure in upper or lower jaw. Technique: Screws from various manufacturers were inserted under local anaesthesia, using a drilled pilot hole. Screws were placed deep enough so that the screw head lay flat with the gum. Immediate loading with a force of up to 150 cN was applied. Mean treatment period = 235 days **Follow-up: not clear (10 months from insertion for the first 133 screws)** Conflict of interest: not stated	**Anchorage success** The average loss rate was 23% (31/133) screws in the first patients treated but decreased to 5% (5/106) in the remaining patients ($p < 0.001$). **Failure rates** (absolute figures not reported)	**Complications** There were no incidents of bleeding, abscess formation or tooth injury (clinically or radiographically proven). Implant losses were accompanied by local inflammation, which healed after implant removal. There were a 'few cases' of mucosal irritation, but this did not lead to screw destabilisation. It was 'rare' that the screw had to be removed for complications such as irritation / patient discomfort or tissue hyperplasia.	Series essentially describes two cohorts of patients: those treated under the original protocol and those treated after a technical adjustment. Treatment was reviewed after the first 133 screws had been inserted, and the parameters for screw size and insertion location were refined. Two clinicians (one orthodontist and one oral-maxillofacial surgeon) undertook the insertions. No details are provided of case selection, or whether this was a consecutive series of patients. One detailed case series is also reported.

	Dual-top screw	Absoanchor screw
First 133 screws	13.0%	30.4%
Subsequent 106 screws	5.2%	3.4%

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Kuroda S (2007)[4] **Case series** Japan Study period: Nov 2000 to Mar 2004 **n = 58 (116 screws)** Population: Male = 16%, Mean age = 22 years. Indications: Patients receiving screw implant as orthodontic anchorage (not further defined). Technique: Type A: inter-maxillary fixation screw, Keisei (n = 37 in 18 patients) Type B: microscrews, Absoanchor (n = 79 in 40 patients) Screws were inserted under local anaesthesia, with the mucoperiostal flap reflected for type A screws, and a drilled pilot hole. Screws were placed with the head extending 2 mm above the mucosa. Two different methods of force loading were used, with 50–200 g force applied. Loading was at 0–12 weeks after insertion. **Follow-up: 14 days** Conflict of Interest: Not stated	**Anchorage success** Procedures were recorded as successful when anchorage could be applied for 1 year or until completion of the orthodontic treatment. **Type A** **Type B** Success rate 81% 89% (absolute figures not reported) Difference not significant There was no significant difference in success rate between screw type and miniplates (n = 38 fitted in 22 patients at the same institution); success rate 87%. In patients treated with type-B screws, the success rate was significantly lower when screws were used for anchorage for tooth intrusion (64% (9/14)) than for orthodontic retraction (95% (57/60) ($p < 0.05$). In patients treated with type-B screws, neither screw length nor loading force was significantly correlated with success rate; success rate was 100% with 200 g loading. **Patient comfort** Pain was recorded on a visual analogue scale where 0 = 'no pain' and 100 = 'pain as much as it could be'. At 1 hour after the insertion procedure, pain was reported by approximately 95% of patients fitted with type A screws, 100% of those with miniplates, and 50% of those fitted with type-B screws. This difference was significant for type B versus type A or miniplate ($p < 0.05$); the difference was still significant at 9 days but not at 14 days. Half the patients who had a type B screw inserted did not use pain medication at any time after surgery.	**Complications** There were no contacts with tooth roots as assessed radiographically. There were significantly fewer reports of swelling, speech difficulty and difficulty with chewing in patients fitted with type-B screws than in those fitted with type-A screws or miniplates at 14 days' follow-up ($p < 0.001$ for both comparisons). There were no significant differences between the groups in the rates of difficulty with tooth brushing.	Data are for all patients in the study, not solely those who received miniscrews. Different clinicians (either orthodontist or oral-maxillofacial surgeon) undertook the insertions depending on type of screw. It is not clear what cut-off point on the visual analogue scale was used to define pain in the analysis between implant types. **Authors state that flap reflection is closely related to pain. In this series, mucosal flap reflection was not required when type B screws were fitted.** No reasons are provided for choice of treatment with either screw type or miniplate.

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Miyawaki S (2003)[3] **Case series** Japan Study period: Mar 1997 to Oct 2001 **n = 44 (134 screws)** Population: male = 18; mean age = 22 years. Indications: Patients with malocclusions receiving implants as orthodontic anchorage for edgewise treatment. Technique: Screw A: 1 × 6 mm (n = 10 in 3 patients) Screw B: 1.5 × 11 mm (n = 101 in 31 patients) Screw C: 2.3 × 14 mm (n = 23 in 10 patients) Screws were inserted under local anaesthesia, with the mucoperiostal flap reflected in some cases, and a drilled pilot hole. Screws were placed into the buccal alveolar bone. Up to 2 N force was applied. **Follow-up: 1 year** Conflict of interest: Study partly supported by government grant	**Anchorage success** Recorded as successful where anchorage could be applied for 1 year or until completion of the orthodontic treatment. Outcome: Type A (n = 3); Type B (n = 31); Type C (n = 10) Success rate: 0%; 84%; 85% (absolute figures not reported; n = no. of patients) There was no significant difference in success rates between type B and type C screws or between type B or C screws and miniplates. Success rate by jaw angle (type B and C screws) (n = no. of patients) Mandibular plane angle: High angle n = 22; Ave. angle n = 13; Low angle n = 6; p value Success rate: 73%; 96%; 100%; < 0.05 Success rate by presence of inflammation (type B and C screws combined) inflammation: Absence (n = 113); Presence (n = 11); p value Success rate: 87%; 54%; < 0.05 There were no significant correlations between implant success and the following variables: screw length, flap reflection, immediate (or postponed) loading, age, sex, crowding of teeth, anteroposterior jaw base relationship, periodontitis or temporomandibular disorder symptoms. Logistic regression analysis showed that the odds ratio for screw failure was 4.6 (95% CI 1.1 to 19.4) with tissue inflammation, and 4.1 (95% CI 1.1 to 15.4) for presence of a high mandibular plane angle ($p < 0.05$ for both). **Patient comfort** Patients who had had flap reflection during implantation complained more frequently of swelling and pain at 1-week follow-up (data not shown).	**Complications** (n = no. of patients) Outcome: Type A n = 3; Type B n = 31; Type C n = 10 Requirement for flap reflection: 0%; 0%; 70% (7/10) Swelling: 0%; 3% (1/31); 70% (7/10) Pain: 0%; 3% (1/31); 60% (6/10)	Data are presented for all patients in the study not solely those who received mini crews. Retrospective case series Potentially some duplication of patients with Kuroda (2007) but study periods overlap by only 1 year, so probably mostly additional patients. Study included for data extraction, as only a small fraction of the implants were plates (17 out of a total of 151 anchors) and outcomes for screws are reported separately. No details given of case selection. Case accrual method is not stated. It is not clear whether this is a consecutive series.

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Chen C-H (2006)[2] **Case series** Taiwan Study period: June 2002 to May 2004 **n = 29 (59 screws)** Population: male = 31%; mean age = 30 years Indications: Patients receiving microscrew implant as skeletal anchorage for orthodontic treatment (not further defined). Technique: All microscrews (Absoanchor), were either 6 or 8 mm length. Screws were inserted under local anaesthesia via a drilled pilot hole, and in some cases a pit created in the cortex with a round burr. Screws were placed in the maxilla or mandible as necessary. Two different methods of force loading were used; 100–200 g force was applied 2 weeks after screw insertion. **Follow-up: 20 months (from insertion)** Conflict of interest: not stated	**Surgical parameters** No patient required an incision or flap creation for screw insertion. The operative time ranged from 10 to 15 minutes (no mean or median given). **Anchorage success** Procedures were recorded as successful if anchorage could be applied until completion of the orthodontic treatment, there was no inflammation or infection, and there was no damage to the tooth root. The overall success rate was 85% (absolute figures not reported). 15% (9/59) of the screws had to be removed; 3 failed before orthodontic force loading and 6 after loading. Success rates were significantly lower for screws inserted into the mandible (81%) than for screws inserted into the maxilla (86%) ($p < 0.05$) (absolute figures not reported). Success rates were significantly lower for 6 mm screws (72%) than for 8 mm screws (90%) ($p < 0.05$) (absolute figures not reported).	**Complications** **Outcome** — **Rate per screw** Broken screw during placement — 3% (2/59) Screw loosened within 3 months — 10% (6/59) Tooth or root damage during placement — 0%	Retrospective case series Only univariate analysis was undertaken to evaluate factors associated with anchorage success. It is possible that confounding factors may have been overlooked (for example, more short screws were inserted in the mandible). Treatment protocol was changed during the series, later patients receiving 8 mm screws in preference to 6 mm screws. Operator experience not stated. The authors state that progression along the learning curve in screw insertion plays an important role in the success rate.

Abbreviations used: CI, confidence intervals

Study details	Key efficacy findings	Key safety findings	Comments
Gelgor I E (2004)[1] **Case series** Hungary Study period: not stated **n = 25 (59 screws)** Population: Male = 28%, age = 11–16 years Indications: Patients receiving microscrew implant as skeletal anchorage for orthodontic treatment (not further defined) Technique: All screws were intraosseous microscrews (IMF Stryker) 14 mm in length. Screws were inserted under local anaesthesia via a drilled pilot hole. The screws were checked radiographically, and mobility was evaluated manually using tweezers. Force loading was done after healing, achieved via a transpalatal arch, with 250 g force applied per side. **Follow-up: 14 months (from insertion)** Conflict of interest: not stated	**Surgical parameters** The operative time ranged from 5 to 8 minutes (no mean or median given). **Anchorage success** All screws were stable after the insertion procedure, and following the distalisation period. The screws were removed when the orthodontic treatment was complete. Some patients did not require local anaesthetic. Primary wound healing was achieved in all patients.	**Complications** No patient required creation of a mucoperiostal flap for screw insertion. No patients reported pain or required analgesia during screw insertion or the distalisation period. Depending on the level of hygiene around the screw, the adjacent tissue showed no or little inflammation. There were no reports of speech perturbation, bleeding or other complications.	Prospective case series Cephalometric evaluation of orthodontic success is reported but this does not relate solely to the screw-implant procedure. No details were provided of patient selection criteria or method of case accrual.

Validity and generalisability of the studies

- Start point of follow-up period is not well defined; this may be from the beginning of treatment (implantation of the screw) or from start of orthodontic procedure.

Specialist advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College.

Dr David Bearn, Dr Jonathan Sandler, Mr Peter Revington

- Two Specialist Advisers considered the procedure to be novel and of uncertain safety and efficacy; one considered it to be an established procedure.
- The potential benefit of the procedure is to provide effective anchorage that is satisfactory for the patient, without the need for tooth extraction or use of external headgear.
- Adverse events reported in the literature or known anecdotally by Specialist Advisers include discomfort on placement, screw failure and screw loosening.
- Additional theoretical complications include infection, swelling or pain at the implant site, displacement of screw, and tooth or nerve damage due to incorrect placement.
- The Specialist Advisers commented that only data from case series are currently available to support efficacy; no comparative data have been published.
- Minimal training is required to undertake what is a technically simple procedure; appropriate training is provided by device suppliers.
- A range of devices is available and operator technique varies to some extent.
- The use of mini / microscrews is common in maxillofacial surgery, and its use is being extended to orthodontics.
- Two RCTs are currently underway in the UK, in Manchester and Chesterfield.

Issues for consideration by IPAC

- There is no generally accepted definition of mini or microscrews. From the literature addressed the screws ranged from 5 to 15 mm long and from 1 to 3 mm wide.
- Some screws appear to require creation of a mucoperiostal flap, which clearly makes the procedure more invasive. It is not clear whether this is an efficacy or safety issue (for example, analogous to a requirement for conversion to open surgery with laparoscopic surgery).
- One theoretical advantage of microscrews is that they are easy to remove; however, no data are available on success of explantation.

- Success rates of screw implantation may differ between the upper and lower jaw because of the differing density of the bones.

References

1 Gelgor IE, Buyukyilmaz T, Karaman AI et al. (2004) Intraosseous screw-supported upper molar distalization. *Angle Orthodontist* 74: 838–850.

2 Chen CH, Chang CS, Hsieh CH et al. (2006) The use of microimplants in orthodontic anchorage. *Journal of Oral & Maxillofacial Surgery* 64: 1209–1213.

3 Miyawaki S, Koyama I, Inoue M et al. (2003) Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *American Journal of Orthodontics & Dentofacial Orthopedics* 124: 373–378.

4 Kuroda S, Sugawara Y, Deguchi T et al. (2007) Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. *American Journal of Orthodontics & Dentofacial Orthopedics* 131: 9–15.

5 Park HS, Jeong SH and Kwon OW. (2006) Factors affecting the clinical success of screw implants used as orthodontic anchorage. [see comment]. *American Journal of Orthodontics & Dentofacial Orthopedics* 130: 18–25.

6 Berens A, Wiechmann D, and Dempf R. (2006) Mini- and micro-screws for temporary skeletal anchorage in orthodontic therapy. *Journal of Orofacial Orthopedics* 67: 450–458.

7 Luzi C, Verna C, and Melsen B. (2007) A prospective clinical investigation of the failure rate of immediately loaded mini-implants used for orthodontic anchorage. *Progress in Orthodontics* 8 (1): 192-198.

Appendix A: Additional papers on mini / micro screw implantation for orthodontic anchorage not included in summary Table 2

The following table outlines studies considered potentially relevant to the overview not included in the main data extraction table (Table 2). It is by no means an exhaustive list of potentially relevant studies.

Article title	Number of patients/ follow-up (FU)	Direction of conclusions	Reasons for non-inclusion in Table 2
Bae SM, Kyung HM. (2006) Mandibular molar intrusion with miniscrew anchorage. *Journal of Clinical Orthodontics* 40 (2): 107–108.	Case report n = 1 FU = 6 months	Two screws provided successful anchorage for orthodontic treatment.	Larger series are included in table 2.
Bohm B, Fuhrmann R. (2006) Clinical application and histological examination of the FAMI screw for skeletal anchorage – A pilot study. *Journal of Orofacial Orthopedics* 67 (3): 175–185.	Case report n = 1 FU = 432 days	A case report demonstrating good osseointegration and a clinically successful outcome	Larger series are included in table 2.
Freudenthaler JW, Haas R and Bantleon HP. (2001) Bicortical titanium screws for critical orthodontic anchorage in the mandible: a preliminary report on clinical applications. *Clinical Oral Implants Research* 12 (4): 358–363.	Case series n = 8 (12 screws) FU = N/S	One screw worked loose and was removed. Other complications included screw-head impingement and slight inflammation.	Larger series are included in table 2.
Fritz U, Ehmer A and Diedrich P. (2004) Clinical suitability of titanium microscrews for orthodontic anchorage-preliminary experiences. *Journal of Orofacial Orthopedics* 65 (5): 410–418.	Case series n = 17 FU = 5 months	The overall screw failure rate was 30%.	Larger series are included in table 2.
Giancotti A, Greco M, Mampieri G et al. (2004) The use of titanium miniscrews for molar protraction in extraction treatment. *Progress in Orthodontics* 5 (2): 236–247.	Case report n = 1 FU = 12 months	Successful anchorage for the 12-month orthodontic treatment.	Larger series are included in table 2.
Herman RJ, Currier GF and Miyake A. (2006) Mini-implant anchorage for maxillary canine retraction: a pilot study. *American Journal of Orthodontics & Dentofacial Orthopedics* 130 (2): 228–235.	Case series n = 16 FU not stated	Success rate depended on treatment protocol and was 100% with the second protocol. Pain comfort was excellent in all but 1 patient.	Larger series are included in table 2.

Kawakami M, Miyawaki S, Noguchi H et al. (2004) Screw-type implants used as anchorage for lingual orthodontic mechanics: a case of bimaxillary protrusion with second premolar extraction. *Angle Orthodontist* 74 (5): 715–719.	Case report n = 1 FU = 29 months	Successful anchorage with 1.5 × 15 mm screws in both upper and lower jaw.	Larger series are included in table 2.
Ko DI, Lim SH and Kim KW. (2006) Treatment of occlusal plane canting using miniscrew anchorage. *World Journal of Orthodontics* 7 (3): 269–278.	Case report n = 2 FU = to 23 months	Successful anchorage and screw removal in both patients.	Larger series are included in table 2.
Maino BG, Bednar J, Pagin P et al. (2003) The spider screw for skeletal anchorage. *Journal of Clinical Orthodontics* 37 (2): 90–97.	Case report n = 3 FU = to 10 months	Successful anchorage in all 3 patients; removal reported in 1.	Larger series are included in table 2.
Ohnishi H, Yagi T, Yasuda Y et al. (2005) A mini-implant for orthodontic anchorage in a deep overbite case. *Angle Orthodontist* 75 (3): 444–452.	Case report n = 1 FU = 21 months	Successful anchorage and screw removal at 21 months.	Larger series are included in table 2.
Paik CH, Woo YJ, Kim J et al. (2002) Use of miniscrews for intermaxillary fixation of lingual-orthodontic surgical patients. *Journal of Clinical Orthodontics* 36 (3): 132–136	Case report n = 1 FU not stated	Successful anchorage	Larger series are included in table 2.
Paik CH, Woo YJ and Boyd RL. (2003) Treatment of an adult patient with vertical maxillary excess using miniscrew fixation. *Journal of Clinical Orthodontics* 37 (8): 423–428	Case report n = 1 FU = 27 months	Successful anchorage with 150– 200 g force per screw	Larger series are included in table 2.
Roth A, Yildirim M and Diedrich P. (2004) Forced eruption with microscrew anchorage for preprosthetic leveling of the gingival margin. Case report. *Journal of Orofacial Orthopedics* 65 (6): 513–519.	Case report n = 1 FU = 3 months	Successful anchorage, and removal after 3 months without anaesthesia	Larger series are included in table 2.
Tseng YC, Hsieh CH, Chen CH et al. (2006) The application of mini-implants for orthodontic anchorage. *International Journal of Oral & Maxillofacial Surgery* 35 (8): 704–707.	Case series n = 25 FU = 16 months		Larger series are included in table 2.
Yao CC, Wu CB, Wu HY et al. (2004) Intrusion of the overerrupted upper left first and second molars by mini-implants with partial-fixed orthodontic appliances: a case report. *Angle Orthodontist* 74 (4): 550–557.	Case report n = 1 FU = 12 months	Successful anchorage with 150–200 g force. Screw removed successfully.	Larger series are included in table 2.
Youn SH. (2006) Midline correction with mini-screw anchorage and lingual appliances. *Journal of Clinical Orthodontics* 40 (5): 314–322.	Case report n = 2 FU = to 16 months	Successful anchorage in both patients. No reports of adverse events.	Larger series are included in table 2.

Appendix B: Related published NICE guidance for mini / micro screw implantation for orthodontic anchorage

Guidance programme	Recommendation
Interventional procedures	None applicable
Technology appraisals	None applicable
Clinical guidelines	None applicable
Public health	None applicable

Appendix C: Literature search for mini / micro screw implantation for orthodontic anchorage

Database	Date searched	Version/files	Comments
CRD databases (DARE & HTA)	07/03/2007	2006, Issue 4	6
CENTRAL	07/03/2007	2006, Issue 4	0
EMBASE	07/03/2007	1980 to 2007 Week 09	284
Medline	07/03/2006	1950 to February Week 3 2007	289
Premedline	07/03/2006	March 06, 2007	15
CINAHL	09/03/2007	1982 to March Week 1 2007	210
BLIC	09/03/2007	-	1
National Research Register	09/03/2007	2006 Issue 4	1
Controlled Trials Registry	09/03/2007	-	1

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in other databases.

Database: Medline
Strategy used: 1 Orthodontics/ (5295) 2 orthodont$.tw. (18928) 3 orthodontol$.tw. (4) 4 ((Teeth$ or Tooth$) adj3 (Correct$ or Move$ or Relocat$)).tw. (2080) 5 Tooth Movement/ (4969) 6 or/1-5 (24049) 7 ((Mini$ or spider$ or bone$) adj3 (anchor$ or screw$ or implant$)).tw. (9660) 8 Bone Screws/ (10232) 9 Orthodontic Anchorage Procedures/ (115) 10 Dental Implants/ (7543) 11 (Dental adj3 implant$).tw. (4381) 12 (orthodontic adj3 (device$ or anchorage$)).tw. (249) 13 TAD.tw. (446) 14 or/7-13 (26787) 15 6 and 14 (643) 16 Animals/ (3990282) 17 Humans/ (9572480) 18 16 not (16 and 17) (3032479) 19 15 not 18 (567) 20 limit 19 to english language (452) 21 limit 20 to yr = "2000 - 2007" (299) 22 from 21 keep 1-299 (299)
Comments: