European Journal of Orthodontics 30 (2008) 330–335
doi:10.1093/ejo/cjn019
Advance Access publication 16 July 2008

Success rate of miniscrews relative to their position to adjacent roots

K. Asscherickx*, B. Vande Vannet*, H. Wehrbein**, and M. M. Sabzevar*
*Vrije Universiteit Brussel, Brussels, Belgium and **Universtätsklinik Mainz, Mainz, Germany

SUMMARY The purpose of this study was to evaluate, histologically, root contact, proximity to a root, and proximity to marginal bone level as possible risk factors for the failure of mini-screws when inserted between neighbouring teeth. Twenty mini-screws were inserted into the mandible of five beagle dogs. Each dog received two bracket screw bone anchors in each lower quadrant, between the roots of the second and third, and third and fourth premolars. Every six weeks, apical radiographs were taken and vital stains were administered. Twenty-five weeks after insertion of the screws, the dogs were sacrificed and specimens prepared for histological evaluation. The distance between the screw and the roots and between the screw and the marginal ridge level (MRL) were measured on the histological slides. The presence or absence of root contact was evaluated histologically on serial sections. The number of screws was too small to allow for sound statistical analysis of the factors under investigation.

During the evaluation period, 11 screws were lost. Six screws were in contact with a tooth root and five of these were lost. In five sites, the distance between the screw and the tooth was less than 1.0 mm, but only one of these screws was lost. The distance between the screw and the marginal bone level was less than 1.0 mm for nine screws and seven of these were lost. The results of this limited study suggest that root contact and marginal position might be major risk factors for screw failure.

Introduction

Anchorage control is one of the most challenging problems in orthodontics. Different devices such as headgear and the use of intermaxillary elastics have been introduced to provide extra anchorage. However, the main disadvantages of this type of anchorage reinforcement are the need for patient compliance and possible undesirable side effects (Egolf *et al.*, 1990). To deal with these problems, implant-like devices have been introduced to provide intraoral, extradental anchorage. The most popular types of implants used are miniscrews, mini-implants, or microscrews. They come in a wide variety of types and designs, with a diameter ranging from 1.2 to 2.0 mm and a length ranging from 6.0 to 12.0 mm. There are many clinical applications as can be concluded from the large number of case reports published on this topic (Chang *et al.*, 2004; Chung *et al.*, 2004; Kyung *et al.*, 2004; Park *et al.*, 2004, 2005; Mah and Bergstrand, 2005; Yun *et al.*, 2005; Bae and Kyung, 2006; Devincenzo, 2006).

The major problem with mini- and microscrews is the failure rate, which is relatively high. Although partial osseointegration of miniscrews has been reported (Vande Vannet *et al.*, 2007), they are not as successful as dental and palatal implants. For dental implants, 5 year cumulative success rates of 90–95 per cent have been reported (Lang *et al.*, 1999) while for palatal implants (Orthosystem®, Straumann, Basel, Switzerland) the success rates vary from 86 to 100 per cent (Wehrbein *et al.*, 1999; Bernhart *et al.*, 2001; Crismani *et al.*, 2006) and for miniscrews from 70 to 90 per cent (Freudenthaler *et al.*, 2001; Miyawaki *et al.*, 2003; Fritz *et al.*, 2004; Liou *et al.*, 2004; Motoyoshi *et al.*, 2006; Park *et al.*, 2006; Kuroda *et al.*, 2007; Wiechmann *et al.*, 2007).

Different factors have been identified to determine success or failure of inserted screws. Mobility (Park *et al.*, 2006), inflammation (Miyawaki *et al.*, 2003; Park *et al.*, 2006), high mandibular plane angle (thin cortical bone; Park *et al.*, 2006), and insertion with a too high placement torque (Motoyoshi *et al.*, 2006) all seem to be factors that might increase the risk of failure.

It is clear that, whenever possible, the insertion site should be chosen in an area of good quality bone and if possible in an area where no tooth is present, for example, the palate, the retromolar area, or in extraction sites or sites of congenitally absent teeth. Most often, the mini-implants are inserted between the roots of neighbouring teeth.

In all the above-mentioned clinical studies, only a part of the implants was inserted between the roots of neighbouring teeth. No distinction was made in failure rate between implants inserted between the roots of neighbouring teeth and those inserted in another region, e.g. extraction site, retromolar area, and palate.

The aim of this study was to evaluate, histologically, if root contact, the distance to the tooth root, and the distance to the marginal ridge of a screw could be identified as risk factors for screw failure.

Materials and method

The miniscrews (Figure 1) used in this study were bracket screw bone anchors (BSBAs). These miniscrews basically consist of two parts: a titanium bone screw, cross-slot, self-tapping, diameter 1.7 mm, length 6.0 mm (Leibinger-Stryker®, GmbH & Co, Freiburg, Germany) and a titanium bracket (Ormco®, Orange, California, USA) with a 0.018 inch slot that is laser welded on the screw (laser apparatus; Bego, Bremen, Germany). The bone screw is not coated or plasma sprayed and is cylindrical in shape.

Experimental animals

Five male beagle dogs (6.5 months old at the beginning of the examination period) were used in this study and housed in the animal centre of Vrije Universiteit Brussel. The general health of the dogs was checked daily by a veterinarian, also responsible for general anaesthesia at the surgical procedure and the evaluation time points. The treatment of the experimental animals was approved by the Ethics Committee for Research on Animals of the Vrije Universiteit Brussel.

Surgical procedure

Insertion of the miniscrews was performed under general anaesthesia. The dogs were first sedated with an intramuscular injection of 0.5 ml Domitor (Orion Corporation, Espoo, (Finland) and 5 mg/kg ketamine (Sanovi, Hannover, Germany). Subsequently they were anaesthetized with an intravenous injection of 5–7 mg/kg Nembutal (Sanovi).

The BSBAs were inserted horizontally (pointing from the buccal to the lingual, as parallel to the occlusal plane and the neighbouring roots as possible). The insertion site was first indicated with a periodontal probe, with which the attached gingiva was punched. A small hole with a diameter of 1.6 mm was immediately drilled through the cortex with a slow-speed hand piece under continuous water irrigation. The BSBAs were inserted manually with a screwdriver that fitted the 0.018 inch bracket slot.

Experimental design

At the start of the examination period, two BSBAs were inserted in each lower quadrant of the dogs between the second and third, and third and fourth premolars. The screws on the left side were loaded immediately after insertion with nitinol closed coil springs (GAC International Inc., Bohemia, New York, USA), exerting a continuous force of 200 g (Figure 2). The screws on the right side were loaded after a healing period of at least 6 weeks.

During the experimental period, all animals were subjected to a protocol of sequential point labelling with single intravenous injections of 7 mg/kg calcein green (Fluka Chemie A.G., Buchs, Switzerland) after 6 and 24 weeks, 30 mg/kg tetracycline hydrochloride (Fluka Chemie A.G.) after 12 weeks, and 90 mg/kg of xylenol orange (Fluka Chemie A.G.) after 18 weeks.

After a period of 25 weeks, the dogs were killed with an overdose of Nembutal (Sanovi) and an intravenous injection of T61 (Sanovi). The parts of the mandible containing the miniscrews were prepared for histological evaluation. The specimens were fixed in 10 per cent buffered formalin for 2 weeks and dehydrated with a graded series of ethanol. The specimens were then embedded in resin. From the resin blocks, 70 μm vertical sections from cranial to caudal (cutting the screws perpendicularly) were obtained. The sections were first evaluated under fluorescence microscopy. Subsequently, the sections were stained with toluidine blue McNeal and examined with a digital light microscope (Leica, Mikroskopie und Systeme GmbH, Wetzlar, Germany).

Success or failure

A screw was considered successful if it was still *in situ* at the end of the examination period (25 weeks after insertion),

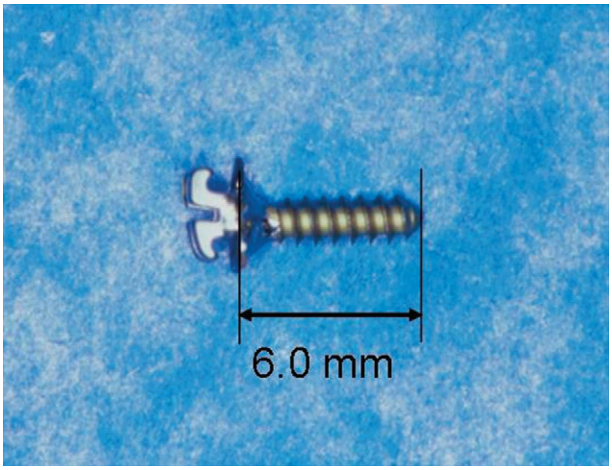

Figure 1 Bracket screw bone anchor.

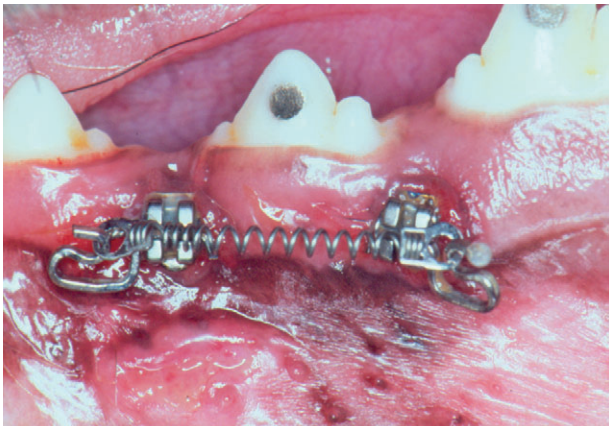

Figure 2 Bracket screw bone anchors inserted between the second and third, and third and fourth premolars in the mandible loaded with a nitinol closed coil spring.

did not show mobility and the sound on percussion was clear.

A screw was considered to have failed, if it was no longer *in situ* or if it had become loose and had to be removed during the examination period.

Four different parameters were evaluated for each individual BSBA.

1. Loading time

   Immediate loading.

   Delayed loading (healing period of at least 6 weeks).

2. Distance between BSBA and marginal ridge level (MRL)

   For all the BSBAs, the distance was measured between the BSBA and the MRL. Because the BSBAs were cut on the histological slides and the widest diameter was not always visible, a circle with a diameter of 1.7 mm (diameter of the mini-screws) was drawn around the part of the BSBA visible on the slide. When no BSBA was present, the circle was drawn according to the former position of the screw, which was determined by evaluation of bone remodelling activity (fluorescence microscopy).

   The distance between the BSBA and the MRL was defined as the distance between the MRL and the most cranial point on the drawn circle (distance measured parallel to the neighbouring teeth; Figure 3).

   To evaluate the distance between the screw and the MRL, the section of the middle part of the screw was used.

3. Distance between BSBA and tooth root (n = 2; distance root 1, distance root 2)

   For all BSBAs, the distance between the BSBA and the tooth root (both sides) was measured (Figure 3). The same circles were used as those to determine the distance between the screws and the MRL. To evaluate the distance between the screw and tooth roots, the section of the middle part of the screw was used.

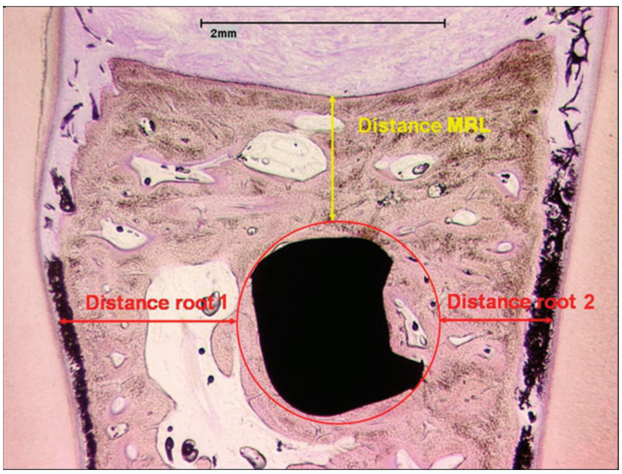

Figure 3 Distances (arrows) measured between the screw and the root (Distance root 1 or 2) and between the screw and the marginal ridge level (Distance MRL).

4. Presence or absence of contact between BSBA and tooth root

   For all BSBAs, histological evaluation was carried out to determine if there was contact between the BSBA and a tooth root. All serial sections of the screws were evaluated.

Statistical analysis

Because of the limited number of screws, no statistical analysis was performed.

Results

Clinical registration

One BSBA (189 LP) was lost after one day and another (188 RA) after two days. Six weeks after insertion, another six BSBAs had failed. Six BSBAs were loaded, after a healing period of at least 6 weeks. Twelve weeks after insertion, another two BSBAs failed, resulting in a total failure rate of 55 per cent. No relationship could be found due to increased gingival inflammation.

Table 1 shows an overview of the time of loading of all 20 implants and the failure or success in function over time. When one of two screws of a pair was lost, the remaining screw was no longer loaded.

At the end of the examination period, only three pairs of implants remained. One pair was loaded immediately after insertion and two pairs, after a healing period of at least 6 weeks.

Histological evaluation

On the histological slides, precise positioning of the screw between the neighbouring roots could be observed. The software Diskus Program—Version 4.20 (Carl Hilgers, Königswinter, Germany) was used to take photographs of and perform measurements on the microscopic images. For the measurements, the histological slides of the middle part of the screws were used.

Table 2 shows an overview of the measurements on the histological slides of all 20 screws.

Six screws were identified as being (or having been) in contact with a tooth root as observed histologically on the serial sections. One of these was still *in situ* at the end of the examination period. Formation of separative cementum lining the root could be observed (Figure 4). For the five other implants which had been in contact with a tooth root and were lost, a defect in a tooth root could be observed (Figures 5a,b).

The distance of the implant to MRL could be easily observed and measured on the histological slides. Eleven implants were inserted too close to the marginal ridge (distance between implant and MRL ≤1.0 mm) and nine of these failed.

All BSBAs placed in contact with a root surface and less than 1.0 mm away from the marginal bone level failed.

For five implants, the distance between the implant and the tooth was less than 1.0 mm, but only one of these implants

Table 1 Loading time of individual bracket screw bone anchors and follow-up of failure (−) or success (+).

Dog and site	Loading time	Six weeks	Twelve weeks	Eighteen weeks	Twenty-five weeks
186 RA	Delayed	+	+	+	+
186 RP	Delayed	+	+	+	+
186 LA	Immediately	+	+	+	+
186 LP	Immediately	+	+	+	+
187 RA	Delayed	+	+	+	+
187 RP	Delayed	+	+	+	+
187 LA	Immediately	+	+	+	+
187 LP	Immediately	+	−	−	−
188 RA	Not	−	−	−	−
188 RP	Not	+	+	−	−
188 LA	Immediately	−	−	−	−
188 LP	Immediately	−	−	−	−
189 RA	Delayed	+	+	+	+
189 RP	Delayed	+	−	−	−
189 LA	Immediately	+	+	+	+
189 LP	Immediately	−	−	−	−
190 RA	Not	−	−	−	−
190 RP	Not	−	−	−	−
190 LA	Immediately	−	−	−	−
190 LP	Immediately	−	−	−	−

R, right mandible; L, left mandible; A, anterior (between second and third premolar); P, posterior (between third and fourth premolar).

Table 2 Individual measurements of the distance to the marginal ridge level (MRL), distance to the neighbouring roots (root 1, root 2), presence of root contact (X), and success (+) or failure (−).

Dog and site	MRL (mm)	Root 1 (mm)	Root 2 (mm)	Success/Failure
186 RA	1.4	0.38	1.3	+
186 RP	1.4	X	1.4	+
186 LA	0	1.0	1.4	+
186 LP	2.8	1.75	0.3	+
187 RA	1.3	1.6	1	+
187 RP	2.4	1.7	0.6	+
187 LA	0	1.9	1.7	+
187 LP	1.3	1.2	X	−
188 RA	0	X	1.4	−
188 RP	0	1.2	1.2	−
188 LA	0	1.0	1.1	−
188 LP	0.75	X	1.2	−
189 RA	1.2	0.5	1.0	+
189 RP	1.9	X	1.1	−
189 LA	2.8	1.4	1.4	+
189 LP	0	0.75	0.4	−
190 RA	0	X	1.37	−
190 RP	0	1.2	1.1	−
190 LA	0	1.1	1.3	−
190 LP	0	1.2	1.1	−

R: right mandible; L: left mandible; A: anterior (between second and third premolar); P, posterior (between third and fourth premolar).

failed. This implant was also inserted too close to the marginal ridge, which could have been the main reason for failure.

Discussion

The use of miniscrews for orthodontic anchorage is increasing and the clinical results are promising. The failure rate however is still too high. Success rates varying from 70 to 90 per cent (Freudenthaler *et al.*, 2001; Miyawaki *et al.*, 2003; Fritz *et al.*, 2004; Liou *et al.*, 2004; Motoyoshi *et al.*, 2006; Park *et al.*, 2006; Kuroda *et al.*, 2007; Wiechmann *et al.*, 2007) have been reported. These percentages are based on studies in which different types of screws were used and with the screws inserted in different regions. None of these investigations used only one type of miniscrew inserted only between the roots of neighbouring teeth. The aim of the present study was to evaluate histologically if root contact, root proximity, or marginal position of a screw could influence the success rate when inserted interradicularly.

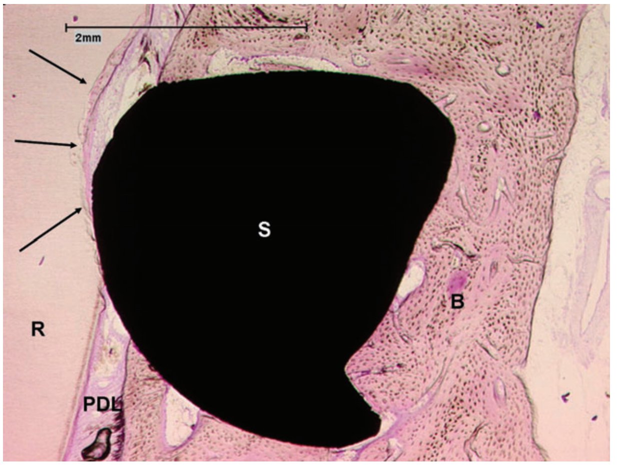

Figure 4 Miniscrew in contact with tooth root. Hypercementosis of the cementum lining the root can be observed (arrows). R, root; B, bone; PDL, periodontal ligament; S, screw.

Since apical radiographs only provide two-dimensional images, they are not suitable for evaluation of different parameters, such as screw–root contact, screw–root distance, and screw–marginal ridge distance. Histological evaluation

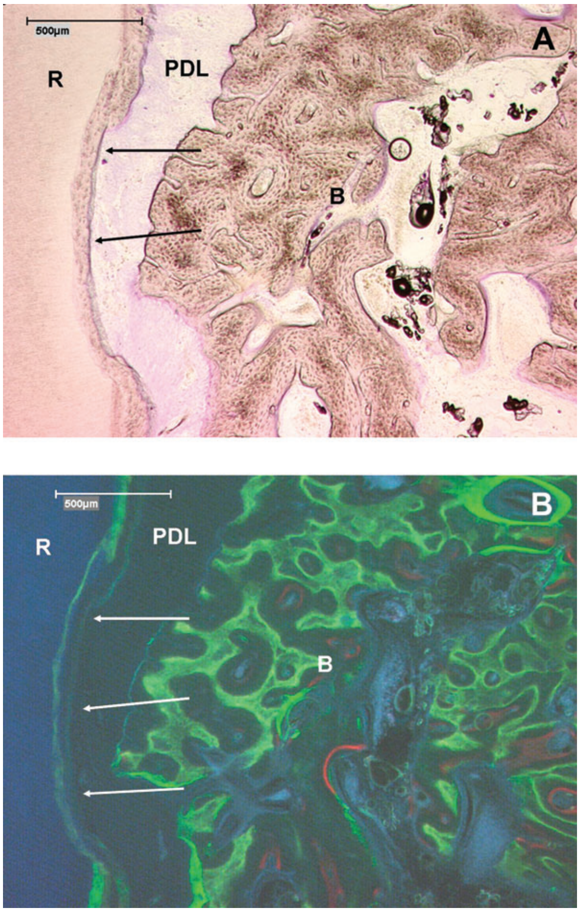

Figure 5 Defect in the tooth root because of previous contact with the mini-screw. Repair of the cementum lining the root can be observed (arrows): (a) light microscopy and (b) fluorescence microscopy. R, root; B, bone; PDL, periodontal ligament.

of the different sections is needed to obtain precise information. For ethical reasons, this cannot be undertaken in humans, and therefore, beagle dogs were chosen as the experimental animals.

According to the results of this study, root contact appears to be a major risk factor for failure of a miniscrew. This is in agreement with a clinical study performed by Kuroda *et al.* (2007). A possible explanation might be that when a screw is in contact with a tooth root, the forces acting on the tooth (mainly biting forces) are directly transferred to the screw. This causes intermittent forces on the surface of the screw, which might result in instability and eventual loss of the screw.

Root contact cannot always be avoided, and radiographs do not provide precise information on screw position. The use of stents and special guides to determine the correct insertion site and angulation for the screws can be helpful, but do not guarantee 100 per cent success in avoiding root contact, when these guides are based on two-dimensional images. It might be better to use three-dimensional images when planning for insertion of miniscrews between the roots of teeth (Kim *et al.*, 2007). This, however, will increase both the cost and radiation dose. By using cone beam computed tomography the radiation dose could be lowered, but the usefulness of surgical guides in terms of the cost/benefit analysis is questionable.

Although the failure rate increases when contact between the screw and a tooth root is present, there does not seem to be permanent problems as a result of root damage, since repair of the cementum and the periodontal ligament can be observed (Asscherickx *et al.*, 2005).

In the present study, the distance between the screw and the root could not be identified as a risk factor for failure. As long as no contact was present between the root and the miniscrew and the distance to marginal ridge was more than 1.0 mm, the success rate was 100 per cent. It is therefore assumed that the forces acting on the neighbouring tooth are absorbed by the periodontal ligament and that the forces which are transferred to the screws through the surrounding bone are insufficient to cause loosening of the screws. Care should however be taken that the tooth root is not moved in the direction of the screw. Huang *et al.* (2005) suggested that the minimum distance between the screw and root should be 1.5 mm. This guideline should be followed in order to avoid contact between the screw and the root after insertion because there is always some difference in angulation when inserting screws. In addition, to minimize potential migration of the screws during initial loading, a safety clearance should be allowed. Thus, when any doubt exists concerning sufficient space between neighbouring teeth, the roots should first be uprighted in the opposite direction.

The marginal position of the screw appears to be another risk factor for screw failure, when inserted in the alveolar process. It has been shown in clinical studies that inflammation is a risk factor for screw failure (Miyawaki *et al.*, 2003; Park *et al.*, 2006). When screws are inserted in the non-attached mucosa, this enhances the risk of inflammation. The available width of attached gingiva in beagle dogs is limited. As the screws were inserted horizontally and, at the same time, in the attached gingiva, this resulted in 10 screws being partly out of the marginal ridge (distance MRL = 0 mm). Eight of these screws failed. It appears to be important that the screw is completely embedded in the bone. When part of the screw is only covered by the gingiva, this might result in forces from biting directly acting on the screws and loosening them. This finding is important because in adult patients with periodontal breakdown, the available width of attached gingiva might also be very small, especially in the mandible, and this can result in a marginal position of the miniscrews. It might be better in these patients to insert the screws with a certain angulation and to ensure that the main part of the endosseous part of the screw is embedded in bone.

The influence of loading time on the failure rate of the miniscrews was difficult to determine from the results of the present study. At the end of the evaluation period, three pairs of screws were still functioning. One pair had been loaded immediately, while the two other pairs were loaded after a healing period of at least 6 weeks. Although the failure rate was higher for the immediately loaded screws, this could have been due to the position of the individual BSBAs. Since it has been shown clinically (Deguchi *et al.*, 2003) that screws can be loaded immediately after insertion, the higher failure rate for the immediately loaded screws was probably due to the more unfavourable individual position of the screws on the left side of the mandible.

In the present study, the pre-drilling insertion method was used. It is conceivable that this insertion method may also have had an impact on failure rate. The amount of screws in contact with a tooth root ($n = 6$) might have been lower if self-drilling screws had been used.

Conclusions

Because of the limited number of screws, no firm conclusions can be drawn from the results of the present study. However, the findings suggest that contact between the screw and the root is a major risk factor for screw failure and a too high marginal position of the screw with part of the endosseous part coming out of the bone is a risk factor for failure of the screw.

Address for correspondence

Karlien Asscherickx
Department of orthodontics
Tandheelkundig Instituut
Vrije Universiteit Brussel
Laarbeeklaan 103
1090 Jette
Belgium
E-mail: kasscher@vub.ac.be

Funding

Department of Research and Development of the Vrije Universiteit Brussel (No. OZR633).

Acknowledgements

We would like to thank Dr Wijffels and his team of the animal centre for their support and Mrs U. Ernst for her expert technical assistance in preparing the slides.

References

Asscherickx K, Vande Vannet B, Sabzevar M M, Wehrbein H 2005 Root repair after injury from mini-screws. Clinical Oral Implants Research 16: 575–578

Bae S M, Kyung H M 2006 Molar intrusion with miniscrew anchorage. Journal of Clinical Orthodontics 40: 107–108

Bernhart T, Freudenthaler J, Dortbudak O, Bantleon H P, Watzek G 2001 Short epithetic implants for orthodontic anchorage in the paramedian region of the palate. A clinical study. Clinical Oral Implants Research 12: 624–631

Chang Y J, Lee H S, Chun Y S 2004 Microscrew anchorage for molar intrusion. Journal of Clinical Orthodontics 38: 325–330

Chung K R, Kim S H, Kook Y A 2004 The C-orthodontic micro-implant. Journal of Clinical Orthodontics 38: 478–486

Crismani A G, Bernhart T, Schwarz K, Celar A G, Bantleon H P, Watzek G 2006 Ninety percent success in palatal implants loaded 1 week after placement: a clinical evaluation by resonance frequency analysis. Clinical Oral Implants Research 17: 445–450

Deguchi T, Takano-Yamamoto T, Kanomi R, Hartsfield J K, Roberts W E, Garetto L P 2003 The use of small titanium screws for orthodontic anchorage. Journal of Dental Research 82: 377–381

Devincenzo J P 2006 A new non-surgical approach for treatment of extreme dolichocephalic malocclusions. Journal of Clinical Orthodontics 15: 161–170

Egolf R J, BeGole E A, Upshaw H S 1990 Factors associated with orthodontic patient compliance with intraoral elastic and head gear wear. American Journal of Orthodontics and Dentofacial Orthopedics 97: 336–348

Freudenthaler J W, Haas R, Bantleon H P 2001 Bicortical titanium screws for critical orthodontic anchorage in the mandible: a preliminary report on clinical applications. Clinical Oral Implants Research 12: 358–363

Fritz U, Ehmer A, Diedrich P 2004 Clinical suitability of titanium microscrews for orthodontic anchorage—preliminary experiences. Journal of Orofacial Orthopedics 65: 410–418

Huang L H, Shotwell J L, Wang H L 2005 Dental implants for orthodontic anchorage. American Journal of Orthodontics and Dentofacial Orthopedics 127: 713–722

Kim S H, Choi Y S, Hwang E H, Chung K R, Kook Y A, Nelson G 2007 Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. American Journal of Orthodontics and Dentofacial Orthopedics 131: S82–S89

Kuroda S, Sugawara Y, Deguchi T, Kyung H M, Takano-Yamamoto T 2007 Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. American Journal of Orthodontics and Dentofacial Orthopedics 131: 9–15

Kyung H M, Park H S, Bae S M, Sung J H, Kim I B 2004 The lingual plain-wire system with micro-implant anchorage. Journal of Clinical Orthodontics 38: 388–395

Lang N P, Karring T, Lindhe J 1999 Proceedings of the 3rd European workshop on periodontology. Implant dentistry. Quintessense Books, Berlin, p. 256

Liou E J, Pai B C, Lin J C 2004 Do mini screws remain stationary under orthodontic forces? American Journal of Orthodontics and Dentofacial Orthopedics 126: 42–47

Mah J, Bergstrand F 2005 Temporary anchorage devices: a status report. Journal of Clinical Orthodontics 39: 132–136

Miyawaki S, Koyama I, Inoue M, Mishima K, Suahara T, Takano-Yamamoto T 2003 Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. American Journal of Orthodontics and Dentofacial Orthopedics 124: 373–378

Motoyoshi M, Hirabyashi M, Uemura M, Shimizu N 2006 Recommended placement torque when tightening an orthodontic mini-implant. Clinical Oral Implants Research 17: 109–114

Park H S, Kwon O W, Sung J H 2004 Uprighting second molars with micro-implant anchorage. Journal of Clinical Orthodontics 38: 100–103

Park Y C, Chu J H, Choi Y J, Choi N C 2005 Extraction space closure with vacuum-formed splints and miniscrew anchorage. Journal of Clinical Orthodontics 39: 76–79

Park H S, Jeong S H, Kwon O W 2006 Factors affecting the clinical success of screw implants used as orthodontic anchorage. American Journal of Orthodontics and Dentofacial Orthopedics 130: 18–25

Vande Vannet B, Sabzevar M M, Wehrbein H, Asscherickx K 2007 Osseointegration of mini-screws. A histomorphometric evaluation. European Journal of Orthodontics 29: 437–442

Wehrbein H, Feifel H, Diedrich P 1999 Palatal implant anchorage reinforcement of posterior teeth: a prospective study. American Journal of Orthodontics and Dentofacial Orthopedics 116: 678–686

Wiechmann D, Meyer U, Büchter A 2007 Success rate of mini- and micro-implants used for orthodontic anchorage: a prospective clinical study. Clinical Oral Implants Research 18: 263–267

Yun S W, Lim W H, Chun Y S 2005 Molar control using indirect miniscrew anchorage. Journal of Clinical Orthodontics 39: 661–664