CHAPTER 2

SYSTEMATIC LITERATURE REVIEW: INSERTION ANGULATION PROTOCOL FOR MINISCREW IMPLANT PLACEMENT INTO THE DENTOALVEOLAR AREA[1]

2.1) Introduction

The use of the bone as an orthodontic anchorage, thus avoiding the loss of dental anchorage and the need of patient compliance in the treatment, has been the focus of several investigations in the last two decades (Odman *et al.*, 1988; Roberts *et al.*, 1994). Initially, the skeletal anchorage was provided by means of conventional dental implants inserted into edentulous areas of the maxilla and mandible (Odman *et al.*, 1988; Roberts *et al.*, 1994). However, the invasiveness of the approach coupled with the elevated costs limited their application for conventional orthodontic treatment (Costa *et al.*, 1998; Huang *et al.*, 2005).

A new generation of implants of reduced size, also known as miniscrew implants, have been recently and specially developed to be used for orthodontic anchorage (Costa *et al.*, 1998; Kanomi, 1997; Kyung S.H. *et al.*, 2003a; Maino *et al.*, 2003; Paik *et al.*, 2002; Park *et al.*, 2001; 2002). Their small size, allied to relatively low cost and the ability to insert them into the dentoalveolar bone between the roots of adjacent teeth, has made miniscrew implants a promising choice in terms of skeletal anchorage (Chung *et al.*, 2004; Kanomi, 1997; Kyung H.M. *et al.*, 2003; Lin and Liou, 2003; Maino *et al.*, 2003; Paik *et al.*, 2002; Park *et al.*, 2001).

The impact of these miniscrew implants for aiding orthodontic anchorage can be confirmed by the increasing number of case series, case reports, review articles, clinical studies and animal and in vitro studies published in recent years (Huja *et al.*, 2006; Kim T.W. *et al.*, 2006; Mavreas, 2006; Xun *et al.*, 2007).

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[1] Thai version of the systematic review was published in the Journal of Dental Association of Thailand (see Appendix B on page 74).

The clinical application of miniscrew implants has also been extensively demonstrated in the literature in the form of protocols describing the surgical procedures (Herman and Cope, 2005; Kyung H.M. *et al.*, 2003; Lin and Liou, 2003; Maino *et al.*, 2003; Melsen and Verna, 2005).

Although these miniscrew implants have confirmed their excellent advantages for providing skeletal anchorage, the potential for failure and for complications is still unpredictable. Several factors have been associated with the failure of the miniscrew implant, such as deficient primary stability (Wilmes *et al.*, 2006), poor bone density (Wilmes *et al.*, 2006), inflammation of peri-implant tissues (Herman and Cope, 2005), lack of attached gingiva (Herman and Cope, 2005), type and size of implant (Buchter *et al.*, 2005; Holmgren *et al.*, 1998), placement technique (Kim *et al.*, 2005), site of placement (Cheng *et al.*, 2004), excessive loading forces (Buchter *et al.*, 2005), and proximity to the roots of adjacent teeth (Deguchi *et al.*, 2006; Ishii *et al.*, 2004; Kim H.J. *et al.*, 2006; Poggio *et al.*, 2006; Schnelle *et al.*, 2004). However, the most frequently cited factor is insufficient primary stability following miniscrew implant insertion (Wilmes *et al.*, 2006). Factors associated with complications of miniscrew implants are the risks of damaging anatomical structures, such as injury to the dental roots and perforation of the maxillary sinus during the placement procedures (Herman and Cope, 2005; Melsen, 2005; Melsen and Verna, 2005).

To overcome these problems, systematic protocols should be followed to allow safe and predictable miniscrew implant placement into the dentoalveolar bone. Recommendations have been suggested by several authors for specific miniscrew implant insertion angles during placement procedures, either to avoid damage to anatomical structures, such as the dental roots, or to increase the surface contact area between the miniscrew and bone, thus improving the mechanical retention of the miniscrew to the bone (Carano *et al.*, 2004; Costa *et al.*, 2006; Cousley and Parberry, 2006; Deguchi *et al.*, 2006; Herman and Cope, 2005; Jeon J.M. *et al.*, 2006; Jeon Y.J. *et al.*, 2006; Kravitz and Kusnoto, 2006; Kyung H.M. *et al.*, 2003; Lee *et al.*, 2001; Maino *et al.*, 2005a; Morea *et al.*, 2005; Park *et al.*, 2001; 2004a; 2004b; 2004c; 2004d; 2005a; 2005b; 2006; Poggio *et al.*, 2006; Suzuki and Buranastidporn, 2005; Wu *et al.*, 2006). However, there is no consensus in the available protocols regarding the proper miniscrew implant angulation to be adopted during the implant placement procedures. Moreover, the influences of such angulations on the biomechanical performance of these miniscrew implants have not been extensively investigated.

The purpose of the this systematic review was to investigate the recommended insertion angulation protocols applied to the placement of miniscrew implants into the dentoalveolar bone, on the basis of all available published scientific literature that met the predetermined criteria for the study design.

2.2) Materials and Methods

2.2.1 Search strategy

To identify all the studies that examined miniscrew implants and insertion angulation protocols, an online literature search was conducted through the most frequently used search engines available in the medical and dental fields, Medline database (Entrez Pub Med, http://www.ncbi.nlm.nih.gov/entrez/) and Scopus (http://www.scopus.com). The survey covered the period from the inception of Medline and Scopus to December 2006 and used the Mesh terms (Medical Subject Headings) “skeletal anchorage”, “miniscrew implant”, “mini-implant”, “micro-screw”, “micro-implant”, “orthodontic” and “temporary anchorage devices”.

2.2.2 Selection criteria

Randomized controlled trials, prospective and retrospective studies, case reports, case series, articles written in English, articles describing surgical procedures and protocols were included. Review articles and letters, animal studies, in vitro studies, articles written in a language other than English, articles that had only the abstract available and technical presentations of an anchorage system, were not considered. Articles describing the use of orthodontic skeletal anchorage provided by means of dental implants, palatal implants, onplants, and miniplates with screws were also excluded.

Abstracts and summaries of all articles were assessed with respect to the inclusion and exclusion criteria. The final selection was made after the researcher read the complete articles. The data were collected and categorized and the results were compared.

For the accurate analysis of the preferred site of miniscrew implant placement, the total number of miniscrews used in all selected articles was calculated and their insertion sites were identified.

2.2.3 Data selection

The following data were collected: author; year of publication; name of journal; study design; type of miniscrew implant; use of placement protocol; recommendations regarding insertion angulation; selected insertion site; evaluation of bone quality; evaluation of soft tissue quality at the implant site (attached or mobile gingiva); assessment of anatomical limitation such as the space between the dental roots; the use of surgical guides, templates or stents; assessment of dentoalveolar bone; assessment of interradicular bone; complications; survival rates; and primary stability. Subsequently, data were analyzed and described in percentages.

2.3) Results

The search strategy resulted in 121 articles. All articles were analyzed according to the inclusion/exclusion criteria. After reviewing all articles, 34 articles were excluded because of the lack of information regarding the protocol for miniscrew implant placement or because of the presence of experimental studies. Finally, 87 articles were selected for the analysis.

Selected articles that met the inclusion criteria were categorized according to study design in two main groups; case reports (n = 59, 67.8%) and original articles (n = 28, 32.2%).

The total number of miniscrew implants used in these studies was 1,336.

2.3.1 Preferred site of miniscrew implant placement

The preferred miniscrew implant insertion sites for orthodontic anchorage in these selected articles (n = 1,336) were; dentoalveolar bone (n = 1,046, 78.3%), retromolar area (n = 52, 3.9%), palatal bone (n = 41, 3.1%), others (zygomatic crest, maxillary tuberosity) (n = 20, 1.5%) (Figure 2.1). The site of miniscrew implant insertion was not specified in 13.2% (n = 177) of reports.

The number of articles describing the use of miniscrew implants placed into the maxillary dentoalveolar bone (n=754, 72.1%) was higher than that of articles describing placement in the mandible (n=292, 27.9%) (Figure 2.2).

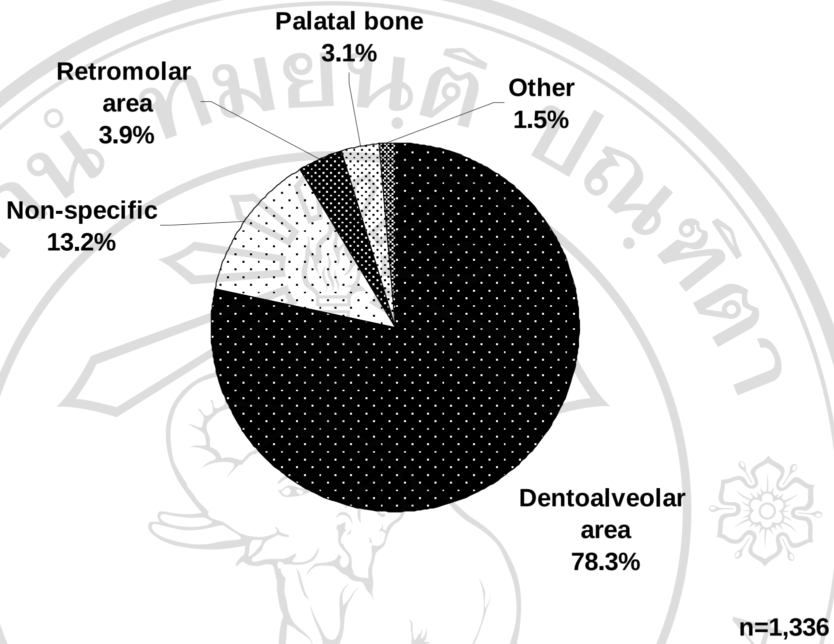

Figure 2.1 Distribution of insertion sites

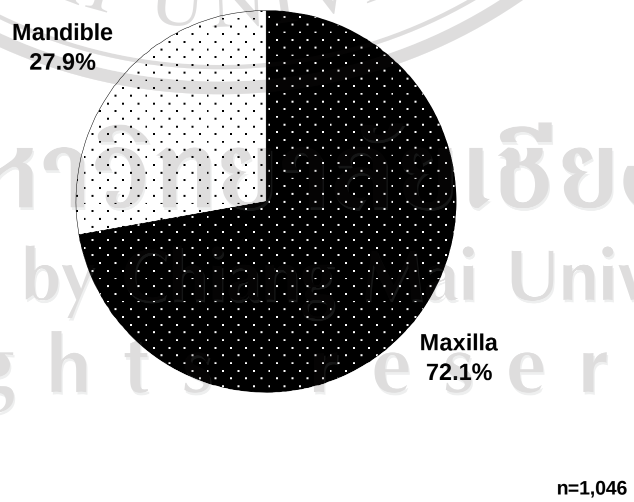

Figure 2.2 Distribution of miniscrew implant sites

There were relatively few articles (n = 5, 6.6 %) examining the adequacy of the preferred implant sites for safe placement (Carano *et al.*, 2004; Deguchi *et al.*, 2006; Ishii *et al.*, 2004; Poggio *et al.*, 2006; Schnelle *et al.*, 2004). These studies concluded that the safest area for miniscrew implant placement into the maxillary dentoalveolar bone was between the maxillary second premolar and first molar, followed by between lateral incisor and canine. The safest area for miniscrew implant placement in the mandible was between the first and second molars, followed by between second premolar and first molar and first premolar and second premolar (Table 2.1).

Table 2.1 Summary of articles identifying safest areas for miniscrew placement

Maxilla	**Mandible**	**Method**	**Reference**
Palatal 5/6	4/5	volumetric CT	Poggio *et al*., 2006
B,Pa 2/3, B,Pa 5/6	-	volumetric CT	Carano *et al*., 2004
5/6	6/7	3D CT	Deguchi *et al*.,2006
5/6	-	Micro CT	Ishii *et al*., 2004
5/6	5/6, 6/7	Panoramic radiograph	Schnelle *et al*., 2004

5, second premolar; 6, first molar; 7; second molar; B, Buccal side; Pa, Palatal side

In these studies, the assessment of available space in the dentoalveolar bone was carried out through volumetric tomography (Carano *et al.*, 2004; Poggio *et al.*, 2006), three-dimensional (3D) CT (Deguchi *et al.*, 2006), micro CT (Ishii *et al.*, 2004) and panoramic radiography (Schnelle *et al.*, 2004).

2.3.2 Methods of miniscrew implant placement

The search strategy resulted in 76 articles referring to the dentoalveolar bone as the preferred recipient area for the miniscrew implant placement.

The placement of miniscrew implants aided by any type of surgical guides was reported in only 20 articles (26.3%). These surgical guides were described mainly as two- or three-dimensional guides, according to the spatial control they offered (Table 2.2).

Table 2.2 Types of surgical guides

Placement guide	**Reference**
Brass wire	Lee *et al.*, 2001
	Park *et al.*, 2004b
	Thiruvenkatachari *et al.*, 2006
	Herman and Cope, 2005
	Chung *et al.*, 2005
	Kyung *et al.*, 2003
	Herman *et al.*, 2006
Acrylic surgical index	Maino *et al.*, 2003; 2005a; 2005b
3D stent	Cousley and Parberry, 2006
Acrylic template	Kyung *et al.*, 2003b
Ceramic ball with bite plate	Kitai *et al.*,2002
Guide bar	Bae *et al.*, 2002
Rectangular wire	Carano *et al.*, 2004; 2005a
3D adjustable surgical guide	Suzuki and Buranastidporn, 2005
Titanium sleeve with vacuum foil	Freudenthaler *et al.*, 2001
Surgical template	Wu *et al.*, 2006
Acrylic resin	Morea *et al.*, 2005

The most common method applied to evaluate the adequacy of the implant site was the periapical radiographic assessment (66.7%), followed by that of the panoramic radiograph (14.8%), CT scan (11.1%), occlusal film (3.7%) and lateral cephalometric radiograph (3.7%) (Figure 2.3).

2.3.3 Miniscrew implant placement angle

Twenty four articles (31.6%) identified the angles of miniscrew implant insertion into the dentoalveolar bone. Different angles of insertion were used for the maxilla and mandible (Table 2.3).

In the maxilla, the most recommended clinical reference for miniscrew implant placement was the long axis of the tooth (62.4%) at the implant site, followed by the bone surface (25.0%) at the implant site, the orientation of orthodontic force vector (4.2%), occlusal plane (4.2%) and long axis of crown (4.2%) (Figure 2.4). For the reference line of the long axis of the tooth, the most recommended insertion angle for placement of miniscrew implants into the maxillary dentoalveolar bone was 30-40 degrees (66.5%), followed by 10-20 degrees (6.7%), 10-45 degrees (6.7%), 30 degrees (6.7%), 45 degrees (6.7%) and 50-70 degrees (6.7%) (Figure 2.5). For the bone surface reference plane, the most recommended miniscrew implant insertion angles were 30-40 degrees (66.6%), 30-45 degrees (16.7%) and 60 degrees (16.7%) (Figure 2.6).

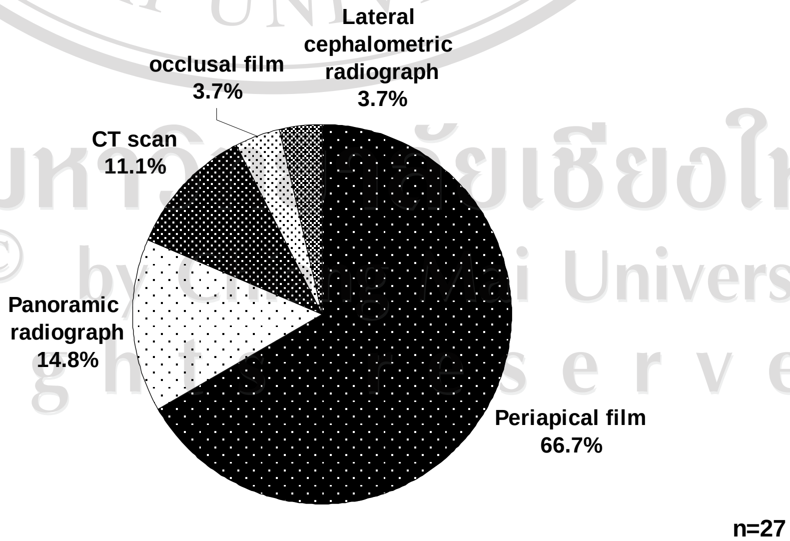

Figure 2.3 Distribution of radiographic methods to evaluate accuracy of implant placement

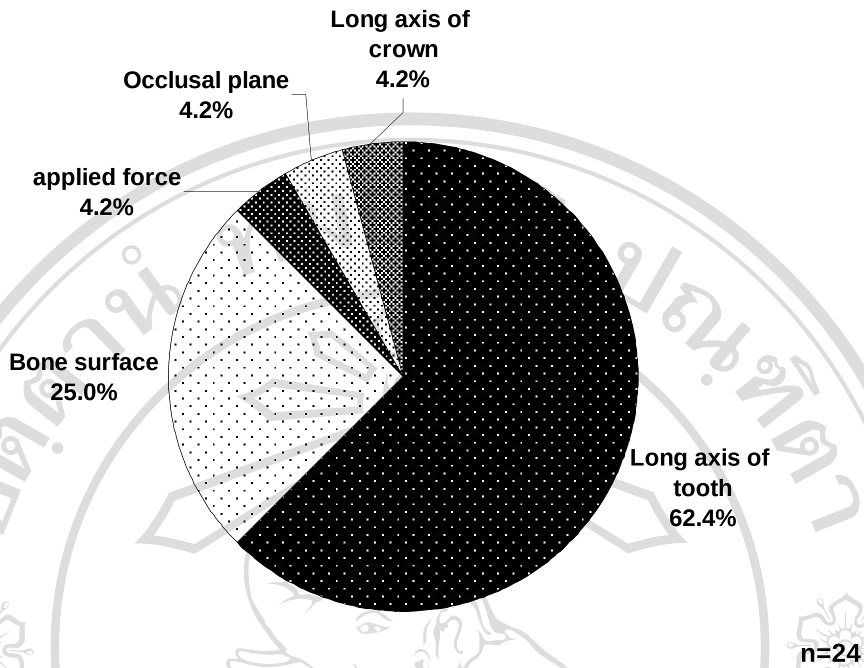

Figure 2.4 Distribution of recommended reference planes in the maxilla

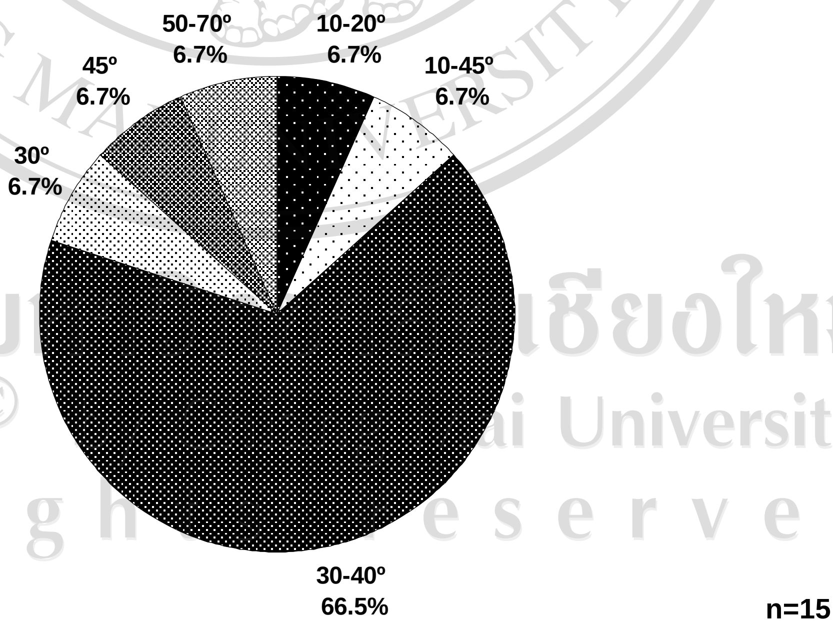

Figure 2.5 Distribution of recommended angulations relative to long axis of tooth reference plane in the maxilla

Table 2.3 Angles of insertion in the maxilla and mandible

Reference	Maxilla	Mandible	Reason
Kravitz and Kusnoto, 2006	40-90° (occlusal plane)		Prevent root damage
		30-45° (occlusal plane)	Increasing contact bone
Wu *et al*., 2006	30-40°	10-20°	No comment
Cousley and Parberry, 2006	45°	-	Prevent root damage
Jeon *et al*., 2006b	30-40°	10-20°	Increasing contact bone
Jeon *et al*., 2006a	30-40° (bone surface)	-	Prevent root damage
Poggio *et al*., 2006	30-40°	30-40°	Increasing bone contact and prevent root damage
Deguchi *et al*.,2006	30°	30°	Increasing bone contact
Herman *et al*., 2006	50-70°	-	Increasing bone contact
Park *et al*., 2006	30-40°	10-20°	Increasing bone contact and prevent root damage
Costa *et al*., 2006	10-45°	10-45°	Prevent root damage
Suzuki and Buranastidporn, 2005	30-40°	30-40°	Increasing bone contact
Morea *et al*., 2005	30-40°	10-20°	Prevent root damage
Herman and Cope, 2005	10-20°	-	Prevent root damage
Park *et al*., 2005b	30-40° (bone surface)	10-20° (bone surface)	Prevent root damage
Park *et al*., 2005a	30-40° (bone surface)	-	Prevent root damage
Park *et al*., 2004a	30-40° (long axis of crown)	30-40° (long axis of crown)	Prevent root damage
Park *et al*., 2004b	30-40°	10-20°	Increasing bone contact and prevent root damage
Park *et al*., 2004d	30-40°	30°	Prevent root damage
Park *et al*., 2004c	30-40°	30-40°	Prevent root damage
Maino *et al*., 2004a	90° (direction of the applied force)	-	Increasing bone contact
Carano *et al*., 2004	30-45° (bone surface)	-	Prevent sinus damage
Kyung *et al*., 2003a	30-40°	10-20°	Increasing bone contact and prevent root damage
Lee *et al*., 2001	30-40° (bone surface)	-	Prevent root damage
Park *et al*., 2001	60° (bone surface)	60° (bone surface)	Prevent root damage

The insertion angulations relative to long axis of tooth

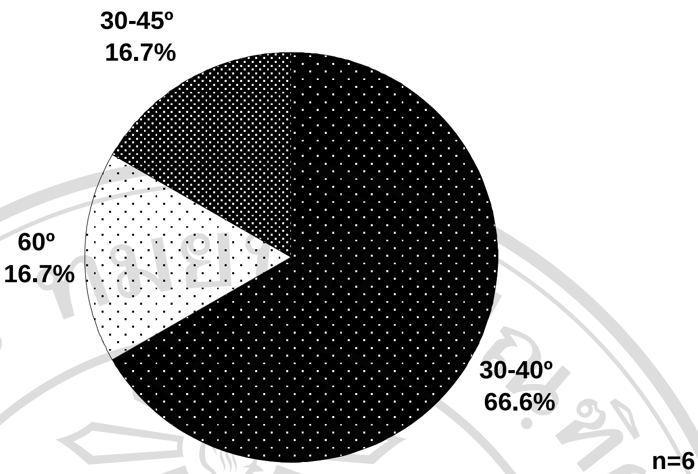

Figure 2.6 Distribution of recommended angulations relative to bone surface reference plane in the maxilla

In the mandible, the most recommended clinical reference for miniscrew implant placement was the long axis of the tooth (75.0 %) at the implant site, followed by bone surface (12.5%) at the implant site and occlusal plane (6.25%) and long axis of crown (6.25%) (Figure 2.7). For the reference line of the long axis of the tooth, the most recommended insertion angle for placement of miniscrew implants into the mandibular dentoalveolar bone was 10-20 degrees (50.0%), followed by 30-40 degrees (25.0%), 30 degrees (16.7%) and 10-45 degrees (8.3%) (Figure 2.8). For the bone surface reference plane, the most recommended miniscrew implant insertion angles were 10-20 degrees (50.0%) and 60 degrees (50.0%) (Figure 2.9).

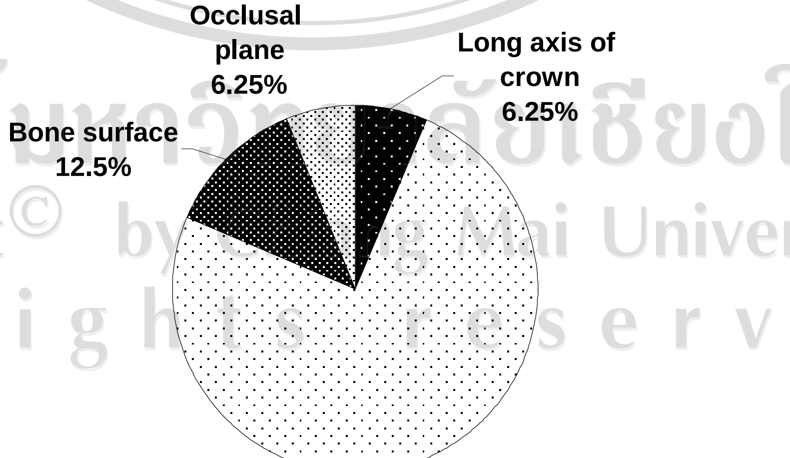

Figure 2.7 Distribution of recommended reference planes in the mandible

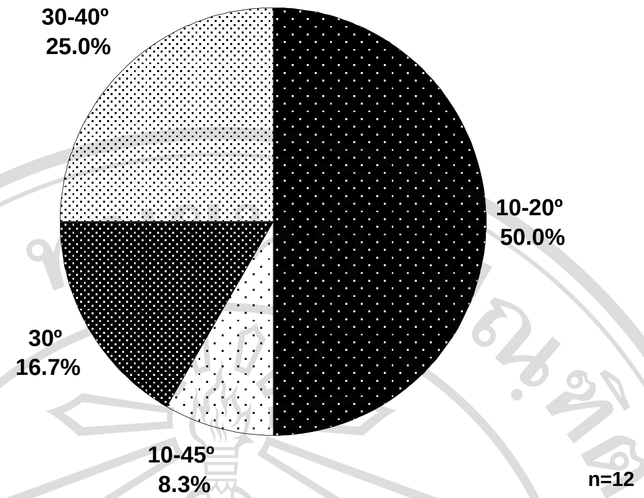

Figure 2.8 Distribution of recommended angulations relative to long axis of tooth reference plane in the mandible

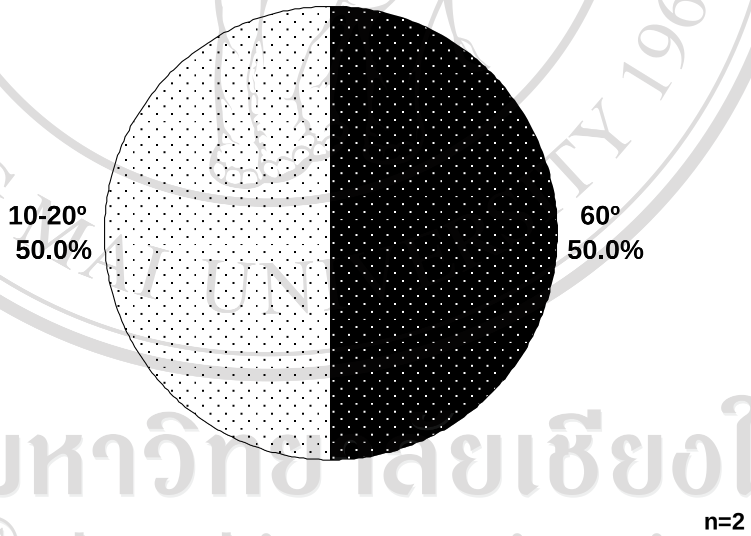

Figure 2.9 Distribution of recommended angulations relative to bone surface reference plane in the mandible

The reason most frequently provided for the use of specific insertion angles was to prevent root damage (54.2%), followed by to obtain more bone surface contact (25.0%), both to prevent root damage and to obtain more bone surface contact (16.7%), and un-specified reasons (4.1%) (Figure 2.10).

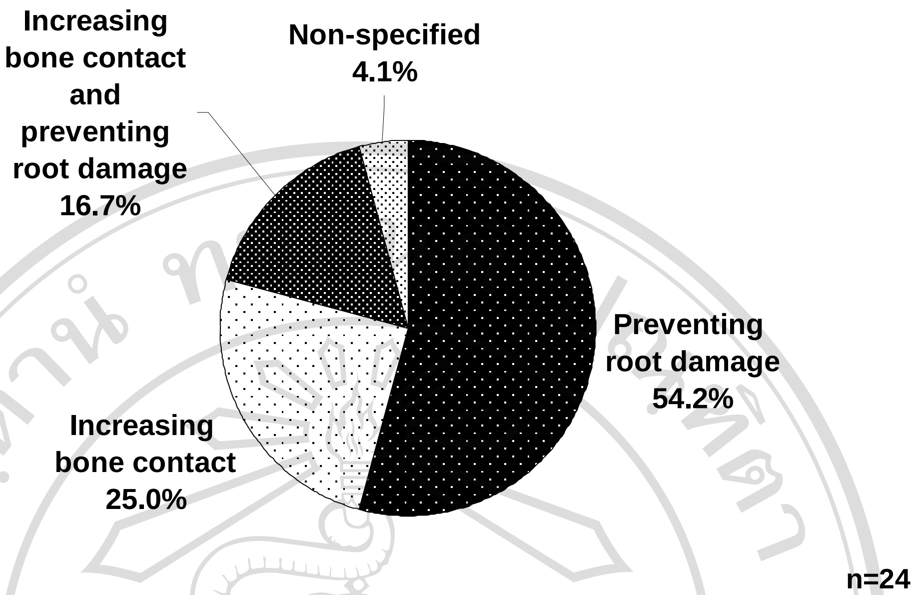

Figure 2.10 Purposes of specific placement angles

2.4) Discussion

The use of skeletal anchorage by means of miniscrew implants has become very popular in orthodontic treatment in a wide variety of cases (Jeon J.M. *et al.*, 2006; Mavreas, 2006; Park, 2006; Xun *et al.*, 2007). However, there is no consensus regarding recommended miniscrew implant insertion angles to be adopted during placement procedures. In this study, although preferred implant sites were identified in several areas of both the maxilla and mandible.

The number of articles describing the application of miniscrew implants in the maxillary dentoalveolar bone (72.1%) was higher than that of articles describing placement in the mandible (27.9%). This difference can be explained by the differences in the bone quality and the thickness of cortical bone between maxilla and mandible. Consequently, reinforcement of dental anchorage is clearly more necessary in the maxillary bone than in the mandibular bone (Chen *et al.*, 2006; Motoyoshi *et al.*, 2005).

The advantage of selecting the dentoalveolar site as the recipient bone to obtain skeletal anchorage is the ability to achieve maximum anchorage while employing relatively simple mechanical delivery force systems, such as elastomeric threads or coil springs (Suzuki and Suzuki, 2007). Moreover, implantation into the dentoalveolar bone allows the orthodontist to perform simple surgical procedures for both inserting and removing the miniscrew implants (Herman and Cope, 2005; Kyung H.M. *et al.*, 2003; Lin and Liou, 2003; Maino *et al.*, 2003; Melsen and Verna, 2005).

Determining the safest miniscrew implant placement site requires careful evaluation of the amount of available interradicular bone between the roots of adjacent teeth (Carano *et al.*, 2005a; Deguchi *et al.*, 2006; Poggio *et al.*, 2006; Schnelle *et al.*, 2004) and of the proximity of the tip of the implant to the maxillary sinus (Ishii *et al.*, 2004). However, the disadvantage of employing the dentoalveolar bone as a recipient site for miniscrew implant placement is that it increases significantly the risks of damaging anatomical structures, such as the dental roots of adjacent teeth or of perforating the maxillary sinus (Ishii *et al.*, 2004; Ohmae *et al.*, 2001; Umemori *et al.*, 1999).

To prevent damage to these anatomical structures, several authors have proposed practical approaches, such as the use of surgical guide devices and specific insertion angles, to aid in the placement of the miniscrew implant into the dentoalveolar bone.

Surgical guides described in the literature were categorized mainly as two- or three-dimensional guides, according to the spatial control of the implant offered by these guides.

Two-dimensional surgical guides include the traditional surgical wire or bar guides. They serve as radiopaque markers to transfer information from the radiograph in the planning stage to the surgical site, and are simple to use (Bae *et al.*, 2002; Carano *et al.*, 2004; 2005a; Chung *et al.*, 2005; Freudenthaler *et al.*, 2001; Herman and Cope, 2005; Herman *et al.*, 2006; Kitai *et al.*, 2002; Kyung H.M. *et al.*, 2003; Kyung S.H. *et al.*, 2003b; Lee *et al.*, 2001; Maino *et al.*, 2003; 2005a; 2005b; Morea *et al.*, 2005; Park *et al.*, 2004b; Thiruvenkatachari *et al.*, 2006; Wu *et al.*, 2006). However, deviation can not be controlled in the trajectory of the drill while creating a pilot hole or during miniscrew implant placement procedures, and may result in significant errors in the final position of the implant. Consequently, they also do not eliminate the potential risk of root injury (Melsen, 2005).

In contrast, three-dimensional surgical guides such as templates, stents and surgical guides for transferring the radiographic, pre-operative, planning information to the surgical site has been proposed for safe miniscrew implant placement into the dentoalveolar bone (Cousley and Parberry, 2006; Suzuki and Buranastidporn, 2005). The radiographic image of the surgical guides is projected onto the recipient bone to orient the ideal miniscrew implant placement position relative to the surrounding structures (Cousley and Parberry, 2006; Suzuki and Buranastidporn, 2005).

Although most of the developed surgical guides presented in the literature claim their advantages in reduction of risk of root damage, only surgical guides with adequate three-dimensional control, both during the pre-operative radiographic planning and the actual implant placement, can effectively aid in accurately determining the insertion angle for miniscrew implants (Cousley and Parberry, 2006; Suzuki and Buranastidporn, 2005). The main advantage of the three-dimensional surgical guides is the ability to transfer the two-dimensional information obtained in the periapical radiograph to the actual implant site (Cousley and Parberry, 2006; Suzuki and Buranastidporn, 2005).

According to the results of this study, although the placement of miniscrew implants into the dentoalveolar area, aided by means of any type of surgical guides, can significantly reduce the risk of root damage, only a minority of the selected articles (26.3%) proposed the use of any type of surgical guiding device.

Another clinical approach to avoid risks of root damage is the use of specific insertion angles during miniscrew implant placement procedures. This clinical approach has been applied by several different protocols (Costa *et al.*, 2006; Cousley and Parberry, 2006; Jeon J.M. *et al.*, 2006; Kravitz and Kusnoto, 2006; Kyung H.M. *et al.*, 2003; Lee *et al.*, 2001; Morea *et al.*, 2005; Park *et al.*, 2001; 2004a; 2004b; 2004c; 2004d; 2005a; 2005b; 2006; Poggio *et al.*, 2006).

Studies have demonstrated that the amount of interradicular bone, both in bucco-lingual (Carano *et al.*, 2004; Ishii *et al.*, 2004; Poggio *et al.*, 2006) and mesio-distal length (Carano *et al.*, 2004; Deguchi *et al.*, 2006; Ishii *et al.*, 2004; Poggio *et al.*, 2006; Schnelle *et al.*, 2004), increases significantly from the crest of the alveolar ridge to the root apex. In addition, in the mesio-distal dimension, the palatal side of interradicular bone is wider than the buccal side (Carano *et al.*, 2004; Ishii *et al.*, 2004; Poggio *et al.*, 2006).

The insertion of a miniscrew implant well above the level of the crest of the alveolar ridge would decrease the risks of damaging the dental roots. However, it would increase the risks of perforating the maxillary sinus. According to Ishii *et al*. (2004) and Poggio *et al*. (2006), the maxillary sinus appeared in an area more than 8-11 mm from the alveolar crest in the root apical direction (Ishii *et al.*, 2004; Poggio *et al.*, 2006). Moreover, insertion in such an area would result in the insertion of the miniscrew implant through the non-attached gingival, and would be more likely to present peri-implant tissue inflammation, resulting in mobility or failure of the miniscrew implant (Cheng *et al.*, 2004; Freudenthaler *et al.*, 2001; Fritz *et al.*, 2004; Miyawaki *et al.*, 2003; Park *et al.*, 2006).

In view of this, by adopting favorable insertion angles during miniscrew placement, the head of the miniscrew implant could be placed through the attached gingival, while the tip of the miniscrew is positioned far from dental roots. Accordingly, the miniscrew implant placement might minimize the risk of damaging critical anatomical structures, such as dental roots.

Although most of the articles suggested angulations of miniscrew implant placement of 30-40 degrees to the maxillary dentoalveolar bone and 10-20 degrees to the mandibular dentoalveolar bone, there was no consistency in the anatomical references for such measurements. For the same recommended angulation, the long axis of the tooth, bone surface and long axis of the dental crown have been suggested. However, the implant angulation may not represent the same angulation when related to these structures.

Another reason suggested for the use of placement angulation was the possibility of increasing the miniscrew implant-to-bone contact surface, thus increasing primary retention (Deguchi *et al.*, 2006; Herman *et al.*, 2006; Jeon Y.J. *et al.*, 2006; Kravitz and Kusnoto, 2006; Kyung H.M. *et al.*, 2003; Maino *et al.*, 2005a; Park *et al.*, 2004b; 2006; Suzuki and Buranastidporn, 2005). The reduced insertion angulation of miniscrew implant to the bone surface increases significantly the surface contact between the miniscrew and cortical bone (Deguchi *et al.*, 2006).

Applying insertion angulation during miniscrew implant placement would, theoretically, increase the overall contact surface between bone and implant, thus improving the biomechanical performances of these miniscrews. However, there is a paucity of studies or clinical trials to support this hypothesis.

An investigation performed by Deguchi *et al*. (2006) evaluated the angulation for miniscrew implant placement to achieve maximum cortical bone thickness. According to the author, the smaller the angulation, the more cortical bone contact to the miniscrew implant. However, the biomechanical performance of these miniscrews was not assessed or investigated.

In this review, a wide range of angulations had been suggested for miniscrew insertion into the dentoalveolar bone of both maxilla and mandible in different protocols. There was no consistency in the anatomical reference to be used for either miniscrew implantation or standardized methods to allow accurate miniscrew insertion angulations. Moreover, aids to allow safe and accurate miniscrew implant placement, such as surgical guides, templates or stents, were applied in only a minority of articles.

2.5) Conclusions

According to the findings of this review we conclude that there are not sufficient evidence-based studies to confirm the hypothesis that the use of reduced miniscrew-bone angulation would improve significantly the biomechanical performance of miniscrew implants. Moreover, it is unknown to what extent the insertion angulation would significantly improve the biomechanical performance of the miniscrew implant in the maxillary or mandibular bone.

The use of insertion angles for miniscrew implant placement has been recommended by only a minority of protocols. Moreover, the use of insertion angles has been recommended mainly to prevent root damage. Although most articles suggested miniscrew implant insertion angles of 30-40 degrees to the maxillary and 10-20 degrees to the mandibular dentoalveolar bone, there was no consistency regarding the anatomical reference for the measurements.

There is no scientific evidence that use of reduced angulation would improve the biomechanical performance of the miniscrew implants. Further studies are necessary to evaluate the effects of insertion angulations on the biomechanical performance of the miniscrew implants.