ABSTRACT

The posterior region of the mid-palatal suture is an appropriate location for placing screw implants. Using safe, multifunctional and solid (SMS) screws, a skeletal anchorage system known as the mid-palatal absolute anchorage system (MAAS) has been developed to withstand more substantial orthodontic forces. In this article, MAAS is introduced and various clinical applications of MAAS in lingual orthodontic treatment are described. MAAS plays a role not only in direct skeletal anchorage (e.g. posterior intrusion, total intrusion, total distalization, anterior retraction and unilateral constriction), but also as indirect skeletal anchorage (e.g. molar distalization). In conjunction with lever arms, MAAS works as an absolute anchorage instrument, with which full control over the axial inclinations of the anterior teeth during retraction is possible. In addition, MAAS drives orthodontic forces not only with respect to individual tooth movements, but also where required to move whole dental arches in any direction with the assistance of a diverse array of power arm configurations and modified lingual arches. MAAS is versatile enough to allow the provision of orthodontic forces in any required direction and can be effectively used as an absolute anchorage device in lingual orthodontic treatment.

INTRODUCTION

Major anatomical factors usually considered during screw insertion include: the thickness and density of cortical bone; the nature and thickness of overlying soft tissues; and the positions of roots, nerves, and blood vessels.

The median and paramedian areas of the posterior palate consist of cortical bone, which is thick and dense enough to support screw implants and can sustain heavy orthodontic forces. These areas have no anatomical structures such as nerves, blood vessels, or roots that can impede the placement of screw implants. Furthermore, most of the soft tissue is keratinized and thinner than 1 mm. Therefore, the posterior region of the mid-palatal suture is safe and solid for inserting screw implants.

A safe, multifunctional and solid (SMS) screw (BioMaterials Korea Inc., Seoul, Korea) has been recently developed, which has a hexagonal head with two cross-shaped 0.032×0.032-inch slots (Fig 1, A). Its diameter is 2 mm and the available lengths are 4 and 5 mm depending on the thickness of the mucosa in the insertion area. Using the SMS screw, a skeletal anchorage system known as the mid-palatal absolute anchorage system (MAAS)
This article describes newly designed MAAS and lingual orthodontic methods using MAAS as adjunct to tooth movement in the various spatial planes.

PROCEDURES FOR MAAS ESTABLISHMENT

A local anesthetic is infiltrated into the desired site of SMS screw implantation. A mouth rinse, with anti-microbial agents such as Hexamedine (Bukwang Phar. Co., Seoul, Korea), is used for 30 seconds. The SMS screw is implanted into the area at the intersection of a line extended between the upper right and left first molars, and the mid-palatal suture (Fig 1, B). Inserting an SMS screw is difficult with a conventional long screwdriver, which forms an oblique angle with the bone surface, changing the direction of the screw and increasing the likelihood of bone damage and implant failure. Therefore, a screwdriver with short length is required (Fig 1, C). After an indicator is placed into the head of the implanted SMS screw (Fig 1, D), an impression is taken. The indicator is used for precise positioning of the SMS screw analogue in the impression. The appropriate form of power arm is fabricated with either 0.032×0.032-inch stainless steel or beta-titanium alloy (TMA) wire on the working cast (Fig 1, E). The fabricated power arm is fixed into the implanted SMS screw head with ligature wire and orthodontic force is applied in the optimal direction to achieve desired tooth movement (Fig 1, F).

CLINICAL APPLICATIONS OF MAAS

Absolute anchorage during anterior retraction

During anterior retraction, MAAS can be utilized not only as absolute anchorage but also for control of anterior torque (Figs 2 and 3). For the purpose of absolute anchorage during retraction, the closing-loop is activated by tie-back of a hook from the power arm in loop mechanics (Fig 2, A and B) and the retraction force is applied from the power arm to the canine hook in sliding mechanics (Fig 2, C and D). MAAS combined with lever arm mechanics is also designed to achieve bodily retraction of the upper anterior teeth without anchorage loss (Fig 3). The length of lever-arm and the application point of force on the power-arm are determined so that the line of action of the retraction force would pass through the center of resistance of the upper 6 anterior teeth.

Total distalization

The distalizing force of entire upper dentition is applied from the power arm to the L-loop of multiloop mushroom archwire (MMAW) between the canine and first premolar on each side in the maxilla (Fig 4).

Molar distalization

After initial alignment, MAAS is constructed to distalize the upper posterior teeth. To distalize the upper second molars, open coil springs are placed between the buccal surfaces of the first and second molars (Fig 5, A). To offset the reactive force to the anterior teeth, a power arm is tied to the first premolar with ligature wire. After distalization of the second molar, the first molar, second and first premolars, and canine are distalized one after
the other until enough space is gained for the lateral incisors. By this time, a new power arm is fabricated and attached to the second molar, in order to use it as absolute anchorage (Fig 5, B).

**Molar intrusion**

A 0.9 mm stainless steel modified TPA with hooks is bonded to the upper posterior teeth and the appropriate power arm placed into the SMS screw (Fig 6). Intrusive force is applied by suspending power chain from the power arm to the modified TPA. The TPA is placed primarily to avoid lingual tipping of the upper posterior teeth, which often occurs during lingual application of intrusive force to the posterior teeth.

**Total intrusion**

A modified lingual arch appliance, with hooks on canines and first molars, is bonded from second molar to second molar in the upper arch and the appropriate power arm placed into the SMS screw (Fig 7). Both the positioning of the hooks and the form of the power arm are determined with the aid of a lateral cephalogram, so that the applied anterior and posterior forces with respect to the center of resistance of the upper dentition as a whole, would move the upper arch posteriorly and superiorly (Fig 8). It is assumed that the center of resistance for the upper dentition from second molar to second molar is located between the roots of second premolar and first molar.

**Unilateral constriction**

In the matter of correction of bilateral posterior crossbite, absolute anchorage is not required because the involved active and reactive forces counterbalance each other during constriction or expansion of the posterior dentition. However, during a unilateral posterior crossbite correction, absolute anchorage is necessary to offset the reactive forces.

To correct the unilateral posterior crossbite, the activated TMA power arm is tied to the upper right posterior brackets (Figs 9 and 10). The power arm is made of TMA instead of stainless steel in order to give flexibility to the power arm.

**DISCUSSION**

Bone height in the mid-sagittal region of the palate was evaluated and the cephalometric assessment was compared with the clinical results obtained during insertion of orthodontic implants. The results of the study suggested that sufficient vertical bone support is available in this area for implants of 4 and 6 mm endosseous length, and a diameter of 3.3 mm. The results also showed that vertical bone support is mid-sagittally at least 2 mm higher than indicated on the cephalogram. Based on the results of the study the length of the SMS screw was decided to avoid the potential risk of a perforation to the nasal cavity.

Because the median palatal region is histomorphologically the best location for orthodontic implant, osseointegrated implants have been used in this area for palatal anchorage. Wehrbein et al clearly demonstrated the value of an implant system (Orthosystem) as absolute anchorage in maxillary premolar...
extraction cases. Byloff and colleagues⁵ have successfully moved molars distally with a Graz-implant-supported Pendulum Appliance. Bernhart et al⁶ indicated that short epithetic implants are suitable to achieve maximum anchorage in the paramedian region of the hard palate in orthodontic treatment. However, these systems require a waiting period of over 2 weeks; immediate loading is impossible; and the methods of placement and removal of the implant are rather complicated and time consuming, as well as costly for the patient because they required surgical intervention.

Recently, miniscrews have been widely used in palatal skeletal anchorage because they are relatively simple to insert and remove, and force can be applied to them almost immediately⁷-¹⁰. Kyung et al⁷ successfully used a miniscrew in the median zone of the palate for distalization of the maxillary molars and Lee at al⁸ used miniscrews in the midpalate for intrusion of upper posterior teeth. Park⁹ used a palatal miniscrew to move the whole frontal group back in lingual orthodontic treatment, and Kircelli et al¹⁰ modified a pendulum for molar distalization with a miniscrew placed palatally in the premaxilla region, obtaining rapid distalization without loss of anchorage. These palatal skeletal anchorage systems play a role as only one form of absolute anchorage. As shown in Figure 5, MAAS can act as various absolute anchorage configurations in treating one case because the SMS screw head has two cross-shaped 0.032×0.032-inch slots and placement and removal of the power arm is possible.

Another important requirement for orthodontic implant anchors is reliable attachment of rigid orthodontic wires. The hexagonal head of SMS screw with two cross-shaped 0.032×0.032-inch slots provides easy placement and removal of power arms fabricated with either 0.032×0.032-inch stainless steel or TMA. Diverse configurations of power arms are fixed in the head of SMS screw with ligature wire and meet the required anchorage force levels according to the case. As shown in this article, SMS screws with or without the power arms can be used as direct skeletal anchorage for intrusion of the upper posterior teeth, total distalization and total intrusion of the upper dentition, upper anterior retraction, and unilateral constriction of upper posterior teeth and as indirect skeletal anchorage for upper molar distalization. The SMS screw is a multifunctional anchorage device.

Many devices for absolute orthodontic anchorage in the maxilla have been introduced and used in the midpalatal region⁴-¹¹. These devices have demonstrated their ability as direct or indirect skeletal anchorage to move individual teeth. As shown in Figure 7, however, MAAS drives orthodontic forces not only with respect to individual tooth movements, but also where required to move whole dental arches in any direction with the assistance of a diverse array of power arm configurations and modified lingual arches.

In our experience, the SMS screw was not stable against rotational movements when the power arm was loaded by a force system generating a moment. This is the case when orthodontic force is applied anteroposteriorly to the power arm. A solution to the rotational moment involves fixing one end of the power arm with the use of ligature wire and activating the other end of the power arm. The fixed end of the power arm is then activated. This allows the stability of the SMS screw against the rotational movement.

CONCLUSIONS

MAAS with the use of SMS screw is versatile enough to allow the provision of orthodontic forces in any required direction and can be effectively used as an absolute anchorage device in lingual orthodontic treatment.
REFERENCES

FIGURE LEGENDS

Figure 1.
A. Dimensions of SMS screw implant.
B. SMS screw is implanted on the area where the extended line of upper right and left first molars and mid-palatal raphe cross.
C. A screwdriver with short length.
D. The indicator is placed into the implanted SMS screw for precise positioning of the SMS screw analogue in the impression.
E. Appropriate form of power arm is fabricated on the working cast model.
F. MAAS constructed for absolute anchorage during retraction of the upper anterior teeth. The closing-loop was activated by the tie-back from the power arm.

Figure 2.
MAAS for absolute anchorage in loop and sliding mechanics.
A. The closing-loop is activated by the tie-back from hook to power arm. Note the SMS screw (SMS).
B. Close-up view. Note the power arm (PA); tie-back hook (TH); and stainless steel ligature wire (SS-LW).
C. The retraction force is applied from the power arm to the canine hook. Note the SMS screw (SMS).
D. Close-up view. Note the power arm (PA); Kobayashi hook (KH); and power chain (PC).

**Figure 3.**

A. MAAS and lever arm for bodily retraction of the upper anterior teeth without anchorage loss. Note the SMS screw (SMS); lever arm (LA); power chain (PC).

B. Schematic drawing of force system for bodily retraction of the anterior teeth. Note the SMS screw (SMS); lever arm (LA); and center of resistance of the six anterior teeth (CR).

**Figure 4.**

MAAS for total distalization of the maxillary dentition. Note the SMS screw (SMS); multi-loop mushroom archwire (MMAW); power arm (PA); and power chain (PC).

**Figure 5.**

A. MAAS for distalization of upper second molars. Note the SMS screw (SMS); open coil spring (OCS); and power arm (PA).

B. MAAS for distalization of upper posterior teeth. Note the newly fabricated power arm (NF-PA).

C. After distalization of upper posterior teeth, the anterior crowding was corrected.

**Figure 6.**

MAAS for intrusion of upper posterior teeth. Note the SMS screw (SMS); modified trans-palatal arch (M-TPA); power arm (PA); and power chain (PC).

**Figure 7.**

MAAS for postero-superior movement of the maxillary dentition.

A. Occlusal view: Orthodontic force is applied postero-superiorly to the maxillary arch by attaching power chains from the power arm to spurs on a modified lingual arch. Note the modified lingual arch (M-LA); and SMS screw (SMS).

B. Close-up view. Note the SMS screw (SMS); power arm (PA); and power chain (PC).

**Figure 8.**

Cephalometric radiographs before (A) and after (B) postero-superior movement of the maxillary dentition. Note the decreased distance from the power arm to spurs on the modified lingual arch. Note the collective center of resistance of the maxillary dentition (CR).

**Figure 9.**

MAAS for unilateral constriction of upper right posterior teeth.

The activated TMA power arm is tied to the upper right posterior brackets to induce lingual movement of the upper right posterior teeth. Note the SMS screw (SMS); power arm (PA).

**Figure 10.**

Models before (A) and after (B) lingual movement of the upper right posterior teeth.
Various Applications of Mid-palatal Absolute Anchorage System Using a Safe, Multifunctional and Solid Screw in Lingual Orthodontic Treatment

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6