The anatomic basis for palatal implants in orthodontics

Orthodontic anchorage without negative reciprocal influences on tooth position can be achieved by the use of immobile implants. An existing dentition permits placement of endosseous implants in only a few regions. These are the edentulous parts of the ridge due to previous extractions, the ascending ramus of the mandible, and the os palatinum. A precondition for successful implant osseointegration is a satisfactory bone base. The midline of the os palatinum is of particular anatomic interest due to the increasing use of anchorage implants in this area. Even though most implants are incorporated uneventfully, in some cases, the osseointegration of these implants fails. Therefore, anatomic data characterizing the palatal midline region are of clinical importance. In this study, trephine bur biopsies provided the material for histologic facings. The donor age covered a span from 12 to 53 years and illustrated that complete ossification of the suture palatina mediana (SPM) is rare before the age of 23 years. Therefore, especially in adult orthodontic treatment, the use of palatal implants should be considered. The anterior SPM is less often ossified than the posterior region. Implant placement should take this into account and consider that a bone bed more favorable to osseointegration might be found posterior to the interconnecting line of the first premolars. (Int J Adult Orthod Orthognath Surg 2002;17:133–139)
Prenatally, the 2 symmetrically originating bone plates of the os palatinum are separated by a wide gap. This gap will be reduced in size by bone apposition until only the SPM remains. From the third year of life, clearly defined layers in the SPM are histologically evident: The bordering bone covers are cortical, inside are spongious structures, and in the center is a highly vascularized part, which disappears around the 21st year. At this time, only fibrous tissue connects the processi palatini, with collagen fibers running parallel to the surface.

In general, the palatal bone is remodeled postnatally by resorption on the nasal surface and apposition of bone on the oral surface. In humans, resorption on the nasal side begins around the seventh year. By the age of 30 years, the volume of spongious bone under the spine nasalis anterior is around 40%. The volume diminishes at 85 years to 10%. The decrease of bone volume is approximately 0.5% to 1.0% per year and is most rapid in women after menopause.

Growth in the SPM is stimulated bioelectrically by tension forces. Under this influence, collagen fibers are osseointegrated by bone apposition on one side and elongated on the other. Tension forces originate from the independent growth of cartilage at the cranial base and within the nasal septum. In humans, around the third decade of life, the maximal width of the palate is reached, combined with increased sutural bone interdigitation.

Björk and Björk and Skieller observed continuing growth of the SPM until 17 years, particularly in the posterior part of the SPM. Other authors also determined that sutural growth ends by the age of 17 years. Altogether, the palatal horizontal extension or width is influenced more in its development by SPM growth than by alveolar ridge growth. It seems that the palatal width continues to increase until 12.5 years in girls and 15 years in boys. In contradiction to Björk’s report, Lang and Baumeister found up to 3.3 cm of palatal width extension after the age of 13 years. Since bone density and height are important for any implant to osseointegrate, all studies regarding the osseous fusion of the SPM are of clinical interest.

Materials and methods

Using a trephine bur, the authors took bone cylinders with a diameter of 0.5 cm and a length of 1.0 cm from the palates of cadavers. The age range of the donors (n = 41) was 12 to 53 years (Fig 1). The main interest focused on the younger subjects (n = 20), since they represented more the usual orthodontic treatment group. The biopsies were taken in the connecting line between the distal side of the first premolar crowns and exactly in the middle of the palate. The trephine bur penetrated the gum surface vertically at an angle of 45 degrees in the frontal direction, as recommended for clinical cases by Wehrbein et al.

The bone cylinders were stored in a 4% formalin solution buffered to pH 7.4 by addition of phosphate. Further preparation of samples followed instructions given by Donath and Breuner regarding the histologic preparation of undecalcified hard tissues.
To analyze the methacrylic embedded material, cuts were ground to a thickness of 30 µm and stained with toluidine blue, which colors acid glycosaminoglycans metachromic, cartilage matrix and mast cells red-violet, osteoid material blue, and mineralized hard tissue light blue.

All specimens were photographed. To demonstrate actual magnification, photos of the specimens were taken alongside a metric ruler. Based on a 10-fold magnification, the SPM length and extension of the SPM ossification were registered. The relationships between SPM length and osseous bridge extension were calculated in percentages. In addition, the minimum SPM value was documented in the photographic prints with 35-fold magnification (Wild microscope type M 420 MPS, Leitz, Germany). Because the sample number was small, no statistical calculations were performed.

Results

The distribution of ossification of SPM is summarized in the contingency table (Table 1). Within the age groups of 23 to 30 years and 32 to 50 years, the frequency of ossified SPM was equal to the number of cases without SPM ossification. The youngest person with SPM ossification was a 23-year-old man. Even though the synostosis was more often visible in elder persons, a wide range of variations was still evident in this group (Figs 2 to 4). Osseous “bridging” speculae of bone in the specimens were sometimes fractured. Six specimens did not qualify for histologic analysis.

To exclude any influence of gender, the material was divided into male (n = 20) and female (n = 5) (Table 2). None of the female SPM were ossified. In the men under 22 years, there was no synostosis, but among the men over 31 years, there was only 1 without SPM ossification (Table 2). Altogether, extensions of SPM ossification (Fig 5) were found in up to 20% of the visible SPM length; the mean value was 8%. In cases without SPM synostosis, there was an age-related decrease in the SPM gap (Fig 6).

The mean distance between the ossified borders of the SPM was 0.03 mm (Fig 7). In some cases, the trephine bur apparently penetrated the canalis incisivus (Fig 8). In one case, a small cyst could be observed in the region of interest (Fig 9). Bone quality and bone quantity were variable.

Discussion

The morphologic structure of bone depends on topography and changes with age.36,38 Truhlar et al discussed the influence of these factors on implant osseointegration.13 Maxillary bone is classified as grade 3 due to a thin corticalis and only relatively dense trabecular structures.9,18 In the midline of the os palatinum the bone is usually around 1.5 cm thick. Extensive bone growth may lead to a torus palatinus, which is rare in Caucasians but often evident in Asians.
Implants intended for orthodontic anchorage should be placed in the interconnection between the first maxillary premolars and exactly in the midline. The biopsies taken reflect bone variations in these areas. In a few cases, the biopsies included the canalis incisivus or the osseous surrounding of this canal (Fig 8) or cystic lesions (Fig 9). This illustrates the existing clinical risk for implant placement: if an implant bone bed is prepared in such an area, complications are likely to occur. Contact with the nerve tissue inside the canalis incisivus will not only cause acute pain (despite anesthesia) but can also permanently damage the nerve. In addition, the lack of dense supporting bone will hinder osseointegration of the implant.

Anatomic data provided by previous studies demonstrate that the amount of bone in the SPM is greatest in the posterior region. This would lead to the conclusion that palatal midline implants would best be placed in a more posterior position. In clinical practice, any bleeding or pain would indicate that the bur has penetrated the canalis incisivus, and the implant must be repositioned.

**Table 2** Correlation of age and gender regarding SPM ossification

<table>
<thead>
<tr>
<th>Age (y)</th>
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<th>Male</th>
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<tr>
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<td>7</td>
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<tr>
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<td>2</td>
<td>5</td>
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<td>5</td>
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Fig 2 Synostotic (upper right region) and non-ossified parts of the SPM. Male, 23 years of age.

Fig 3 The SPM is characterized by a curved morphology, with wider and smaller distances of the non-ossified fibrous midline suture. Male, 45 years of age.

Fig 4 Palatal midline suture, with regions of variable gaps between the bilateral bone plates of the os palatinum. Female, 35 years of age.
Our findings cannot definitively determine the extent to which age-related synostosis of the SPM can influence the osseointegration of implants and thus also the success rate. It was evident that subjects who were male and older than 23 years displayed ossified SPMs more often. The clinical failure rate of implants placed for palatal anchorage might be therefore higher in women. Published data and our observations show the tendency of the SPM to become smaller with age due to bone apposition and suture ossification. This begins no earlier than 17 years, so the failure rate of palatal implants should be higher in patients under 17 years. Ossification of the SPM creates greater stability, but on the other hand the postulated shock-absorbing effect of the SPM will disappear with ossification.

There was variation in ossification grades in the SPM in our material compared with data published by Persson and Thilander, who refer to about 33.5%, compared to only 8% seen here, even though the age groups were the same. This can be explained by the different locations of the biopsies. In the anterior part of the SPM, they also found only about 7% SPM ossifications.

In general, any report based on a histologic analysis cannot be compared with radiologic findings regarding SPM ossification. On radiographs, the 3-dimensional reality is reduced to a 2-dimensional picture with...
overlapping bone structures, which can give the illusion that the SPM is ossified. Only histologic specimens represent the correct segmental replica of the anatomic reality.

The significantly diminished distance between the osseous borders of the SPM during aging is an expression of the vertical interdigitation of the sutures and thus increased possibility to discover osseous structures. Persson and Thilander described a high degree of fusion activity, with impressive interindividual variation from 20 to 25 years. In 8 persons under 21 years, the OI was 7 times less than 0.1%.

Many papers report a lower grade of SPM ossification in women than in men. This is also evident in our material. This finding is astonishing, since the OI and also the SMI usually indicate earlier osseous maturity in girls.

**Clinical conclusions**

Palatal implants are a valuable clinical alternative to headgear treatment in orthodontics. Headgear efficacy depends on patient compliance and can cause orbital damage. Orthodontic treatment using palatal implant anchorage offers enhanced patient comfort due to the “invisible” appliance and gives the orthodontist the guarantee that the applied orthodontic forces cannot be interrupted by the patient’s noncompliance.

Although implant placement is a minor surgical intervention, patients want to be sure that this procedure is risk-free and successful. Palatal implants (like any others) require supporting bone for osseointegration. Therefore, the aim of our study was to explore the osseous structures in the area in which orthodontic implants are most often placed, ie, the palatal midline at the first premolar level. Our findings indicate that osseointegration of implants in the palatal midline may fail due to incomplete osseous closure of the SPM. A gap between the osseous wings of the SPM is more evident in the anterior and less in the posterior region of the SPM.

However, the clinician must understand that the risk of failing implants, according to these anatomic findings, is still low. The SPM fibrous fissure is approximately 0.03 cm, compared with the typical implant diameter of 0.4 cm. This explains why implants in a region without complete osseous fusion can still osseointegrate. These implant sizes explain also why, despite the fissure ossification data, palatal midline implants are effective even in patients under 20 years of age.

Clinicians will doubtless realize during bone bed drilling when the chosen implant localization is too risky. Site-preparation methods such as bone condensation or cytokine application (platelet-rich plasma, bone morphogenetic proteins, etc) may be helpful in such cases. The relocation of the implant to a more posterior position may be an even better solution.

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**References**
