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Success rate of paramedian palatal implants in adolescent and adult orthodontic patients: a retrospective cohort study

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SUMMARY The purpose of this study was to examine the success rate of paramedian palatal Orthosystem first- and second-generation implants used for anchorage in orthodontic treatment in patients treated by one experienced orthodontist.

The records of 143 patients (90 female, 53 male, median age: 15.7 years, range: 10.2–50.9) receiving 145 palatal implants of the first or second generation (Orthosystem, Straumann AG, Basel, Switzerland) were examined. All the palatal implants were placed in a paramedian palatal location by three experienced surgeons. Stable implants were orthodontically loaded after a healing period of 3 months. Out of the 145 inserted paramedian palatal implants only seven implants (4.8%) were not considered stable after insertion. All the successfully osseointegrated implants remained stable during orthodontic treatment.

Paramedian palatal implants are highly reliable and effective devices to obtain skeletal anchorage for orthodontic treatment. This study has shown that the paramedian location is a good alternative to the median location.

Introduction

Controlled tooth movement and anchorage are important considerations during orthodontic treatment planning, especially in extraction cases and in adult orthodontics where intact dentitions are not present. Ideally, orthodontic anchorage should provide complete interception of all undesirable side-effects associated with the desired tooth movement. Traditional solutions to obtain anchorage in orthodontic treatment include headgears, Nance appliances, transpalatal and lingual arches, or a combination of the above, for which however success relies on compliance. The concept of complete anchorage seems to be realized in the form of temporary orthodontic skeletal anchorage devices (TAD) that include variations of miniscrews, miniplates, and palatal implants (Tsui *et al.*, 2012). According to Feldmann *et al.* (2012), it appears that skeletal and conventional anchorage systems as adjuncts to orthodontic treatment are perceived in a similar manner by patients.

Depending on the orthodontic movement required, it could be in many cases advantageous if TADs are placed in other regions than in the interradicular alveolar bone. The possible regions of the hard palate are in the mid-sagittal plane (Triaca *et al.*, 1992; Wehrbein *et al.*, 1996; Stockmann *et al.*, 2009) or at paramedian locations (Bernhart *et al.*, 2000, 2001). The median-sagittal area may be characterized by relatively low vertical bone support, so the paramedian region is a good alternative to place the palatal implants (Bernhart *et al.*, 2000; Alsamak *et al.*, 2012).

A recent systematic review of bone anchor systems for orthodontic application showed generally high success rate with some variability between the different anchorage systems: 91.4–100% for miniplates, 74–93.3% for palatal implants, and 61–100% for miniscrews (Tsui *et al.*, 2012).

There are only a few studies assessing success rates of palatal and in particular paramedian implants for anchorage in orthodontic treatment (Bernhart *et al.*, 2000, 2001). The aim of this retrospective cohort study was to evaluate the success rate of paramedian located palatal implants of the first and second generation of Orthosystem (Straumann AG, Basel, Switzerland) during orthodontic treatment in a relatively large orthodontic patient cohort.

Materials and methods

Selection of the sample

The records of 143 patients who received a total of 145 palatal implants of the first and second generation (Orthosystem; Straumann AG, Basel, Switzerland) were chosen from a private practice in Switzerland (JG, Langenthal) and were retrospectively examined. Two of the included patients received a second implant because the first implant was lost. All the palatal implants were placed in a paramedian palatal location by three experienced surgeons. There were no specific exclusion/inclusion criteria; the only criterion to include a patient into the study was that the patient received a palatal implant and therefore all patients of this private practice who were treated with a palatal implant were included in the study.

Method of implant insertion

Before the palatal implants were placed, the vertical bone volume was assessed in lateral cephalograms (Wehrbein *et al.*, 1999). All palatal implants were inserted under superficial and subsequent local anaesthesia in the anterior palate region, paramedian to the palatal suture. After injecting the local anaesthetic, the palatal mucosa was removed with a punch and an elevator. A round drill was used to mark the cortical bone at the implant insertion and a spiral drill was utilized in order to prepare the implant accommodating hole. Finally, the shoulder was prepared with an ortho-profile drill and the implant itself, which is self-cutting, was inserted by hand with a ratchet.

All patients were informed that they had to avoid contact of the screw with their tongue or fingers. The healing process and the hygiene status were examined and controlled in all subsequent appointments. In the absence of implant mobility and persistent subjective complaints, the osseointegration was defined as successful (Buser *et al.*, 1990). An implant was considered a failure if it presented some mobility after applying light forces only with tweezers.

Type of orthodontic appliance

In 138 out of the 143 patients (median age: 15.7 years and range: 10.2–50.9), the palatal implants osseointegrated successfully and were clinically stable after a healing time of 10 weeks. An alginate impression was taken in order to obtain a plaster cast for designing the individualized, rotationally stable supraconstruction.

An appliance was placed in the mouth 3 months after inserting the palatal implant. Fabrication of the appliances, which were mostly transpalatal arches (TPA, n = 134) fixed to the molars or premolars, was accomplished by taking an impression with special abutments on the palatal implants. These transpalatal arches were bonded to the teeth with a light-cured adhesive (Transbond XT, 3M Unitek, Monrovia, California, USA).

In four cases, patients received various other devices, such as Pendulum or leverarms. When the implants were no longer needed they were removed using a standard trephine. Only one patient had a secondary bleeding after the explantation; no other complications were observed.

Data collection

All data for the 143 patients were collected at the private practice of the orthodontist (JG) in Switzerland who was responsible for patient selection and for carrying out the orthodontic therapy.

For each patient, the following data were collected for the study: medical and dental history, gender, age, date of palatal implant insertion, type of appliance, date of appliance insertion, biological and technical complications, date of the appliance removal, and date of palatal implant removal. Microsoft Excel software was used for data collection.

Statistical analysis

Time to implant success was explored with statistical methods for survival analysis. Clustering effects were not considered as only 2 patients out of 143 received a second implant after failure of the first one. All analyses were done with the STATA statistical package (version 12.1, StataCorp, College Station, Texas, USA).

Results

One hundred and forty-five paramedian implants were inserted in 143 patients, 90 females (63%) and 53 males (37%). The median age was 15.7 years and range was 10.2–50.9 years. In two boys, two palatal implants inserted as the first implants were not primary stable. All implants were inserted in the same paramedian region of the palate by three experienced clinicians (131, 13, and 1 implants inserted per surgeon, respectively) from November 2001 to March 2011. In total, seven palatal implants were lost, three in females and four in males. For first-generation implants, the proportion of failure was 3/97 (3.1%) and for second generation 4/48 (8.5%) (P = 0.15 from Fisher's exact test). All implant failures were from the same surgeon who has placed most of the implants.

After insertion of the appliance, 134 palatal implants (97.1%) were used for passive stabilization and four implants (2.9%) were used for active loading. The majority of the TPAs were bonded symmetrically to the first premolars (n = 12), the second premolars (n = 31), the first molars (n = 80), or the second molars (n = 2). Only five TPAs were bonded asymmetrically. In four cases, the TPA was removed during the orthodontic treatment and substituted by a different appliance. None of the successfully osseointegrated implant was lost under orthodontic loading. Afterward the palatal implants were removed using a standard triphine.

At the end of the study 39 palatal implants were still *in situ* for the following reasons: orthodontic treatment is still in progress (n = 21) or just after appliance removal but before explantation (n = 12), patients did not return as they were afraid of the implant removal process (n = 2) or patients were lost to follow-up after orthodontic treatment (n = 4). A total of 106 palatal implants had been already removed due to completion of orthodontic treatment (99) or implant failure before successful osseointegration (7). Neither biological nor technical complications were detected apart from palatal implant loss.

The success rate was calculated based on the time period between placing and removing the palatal implant. The number of successful implants, mean, median, minimum, and maximum number of months of successful implant retention overall and by gender are displayed in Table 1.

Implant failure was defined as lack of osseointegration or if the implant showed mobility.

The Kaplan–Meier survival estimate for all participants are shown in Figure 1, whereas the survival estimate by gender is shown in Figure 2. It is evident from Table 1 and Figures 1 and 2 that the implant success rate was excellent. Table 2 shows failures for different age groups.

Discussion

Skeletal anchorage is gaining increasing attention among clinicians, as they deliver absolute anchorage control and require no compliance. Palatal implants in orthodontic treatment must be positionally stable to serve as absolute anchorage for orthodontic tooth movements, and therefore, osseointegration is desirable. Wehrbein *et al.* (1998) showed that osseointegration is maintained during orthodontic loading under clinical conditions with histological examination of explanted palatal implants. This suggests that adequate anchorage can be achieved also with these small implants.

The purpose of this study was to assess the success rate of paramedian palatal implants (Straumann Orthosystem first and second generation). In our study, some patients experienced premature loss of the implant before orthodontic appliance insertion, which may be attributed to insufficient primary stability that causes connective tissue encapsulation or insufficient wound healing (Friberg *et al.*, 1991, Lioubavina-Hack *et al.*, 2006).

The overall success rate of paramedian palatal implants in our study reached 95.2% and is high in comparison with other similar studies. Most of these studies showed the success rates of median palatal implants (Crismani *et al.*, 2006, 90%), (Feldmann and Bondemark, 2008, 93.3%), (Jackson *et al.*, 2008, 86.9%), (Jung *et al.*, 2009, 93.3%), (Jung *et al.*, 2012, 95.4%) (Männchen *et al.*, 2008, 94.3%), (Sandler *et al.*, 2008, 74%), and (Wehrbein *et al.*, 2009, 90.9%). Only one small study reported success rates of 21 paramedian palatal implants of a different type (Bernhart *et al.*, 2001, 85.7%). This study is the first analyzing such a large number ($n = 145$) of paramedian palatal implants. Jung *et al.* (2012) reported that demographical and radiological parameters had no impact on implant loss and that the surgeon's experience is key to palatal implant success.

Table 1 Number of successful implants, median, mean, minimum, and maximum number of months of follow-up overall and by gender.

	Total	Successful implants	Median follow-up time (months)	Mean follow-up time (months)	Range of follow-up time (months)
Male	55	51	32.7	32.3	0.1–60.0
Female	90	87	37.4	37.6	0.4–91.3
All	145	138	35.5	35.6	0.1–91.3

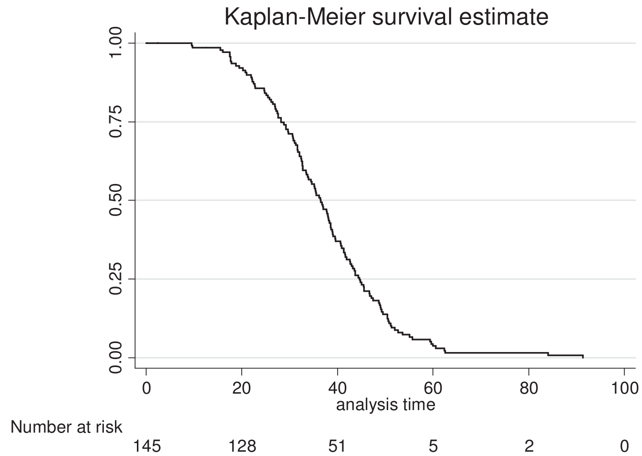

Figure 1 Kaplan–Meier survival estimate for all participants. The y-axis provides the proportion of patients still with stable implants at different time points (months on x-axis). By drawing a line perpendicular to the x-axis at a given time value, the proportions of patients prior to implant removal are extrapolated from the corresponding value of the y-axis.

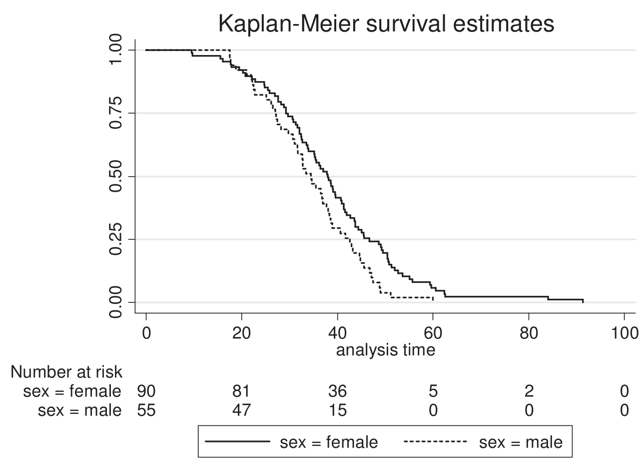

Figure 2 Kaplan–Meier survival estimate by gender. The y-axis provides the proportion of patients still with stable implants at different time points (months on x-axis). By drawing a line perpendicular to the x-axis at a given time value, the proportions of patients not completed for each gender group are extrapolated from the corresponding value of the y-axis.

Table 2 Implant failure by age group.

Age category (years)	Failures
<14.1	0/36 (0.0%)
14.2–15.7	3/35 (8.6 %)
15.8–17.6	2/37 (5.4%)
>17.8	2/37 (5.4%)
Overall	7/145 (4.8%)

Despite the fact that palatal implants seem to be in general superior to miniscrews (Tsui *et al.*, 2012), for practical reasons, the introduction of the latter (Kanomi, 1997; Costa *et al.*, 1998) was followed by a decrease in the popularity of the former. As no large studies on stability of miniscrews placed in the paramedian region of the anterior palate are available, no direct comparison between paramedian miniscrews and palatal implants can be made.

The report of Asscherickx *et al.* (2005) has raised the issue of growth interference when the palatal implants are placed in the midline. An initial suspicion of disturbed transverse growth following insertion of palatal implants in the mid-sagittal plane could be provided with experimental data obtained from growing beagle dogs.

The limitations of the present study may be attributed mainly to its retrospective nature. Retrospective data collection may introduce selection and detection bias. To reduce selection bias, all the patients who received a palatal implant were included in this study. Detection bias is unlikely to be an issue as implant loss is a hard outcome and therefore less prone to manipulation.

The results of this study may be applicable to other setting given the excellent success rate across gender and age groups, however, implant, equipment, and experienced surgeons and staff availability may be important success predictors in the use of paramedian implants for absolute anchorage control in orthodontics.

Conclusions

- The orthodontic palatal implants Orthosystem first and second generation (Straumann AG, Basel, Switzerland) appear to be reliable options for skeletal anchorage in orthodontic treatment.
- The risk of failure of paramedian palatal implants was low (4.8%) and was encountered only during the healing period. After successful osseointegration, no palatal implant was lost under orthodontic loading.

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