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Success rate of palatal orthodontic implants: a prospective longitudinal study

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Abstract

Aim: The purpose of this prospective cohort study was to assess the survival and success rates of palatal implants.

Material and methods: Seventy patients (56 female, 14 male; age 25-6 ± 10-8 years) receiving Orthosystem® (Straumann AG, Basel, Switzerland) palatal implants from March 1999 to November 2006 were included. The indication was established according to the required anchorage for orthodontic therapy. All implants were placed in a mid-sagittal, median or paramedian palatal location by the same surgeon. They were orthodontically loaded after a healing period of 8–16 weeks (Mean: 12.8 weeks).

Results and discussion: Of the initially 70 consecutively admitted patients, two implants in two patients were not primary stable after installation and had to be removed. Of the 70 initially installed palatal implants, 67 implants or 95.7% osseointegrated successfully and were loaded actively and/or passively for approximately 19 months. Only one implant of the 67 osseointegrated implants lost its stability under orthodontic loading. By the time of re-evaluation, 20 palatal implants were still used for orthodontic therapy, while 46 implants had been removed after completed orthodontic therapy. By only analyzing those, the success rate of the initially installed implants was 92%.

Conclusions: Orthodontic palatal implants with a rough surface are predictable and highly reliable devices for a multitude of maxillary orthodontic treatment options. The survival and success rates for palatal orthodontic implants are comparable to dental implants installed for dental prostheses.

Numerous case reports and clinical trials have been published documenting the possibility of using different types of temporarily placed anchorage devices (TAD) fixed to bone, which are subsequently removed after their use for the purpose of enhancing orthodontic anchorage or overcoming the limitations of traditional anchorage. The anchorage by means of a TAD permits an independency of patient compliance (Creekmore & Eklund 1983) either by supporting the teeth of the reactive unit or by obviating the need for a reactive unit altogether.

Because regular orthodontic patients have a full dentition or extraction sites to be closed, no edentulous alveolar bone sections are available for the insertion of an implant. As a consequence, implants for orthodontic anchorage purposes must be placed in other topographical regions. In the early 1990s special implants have been introduced to serve as temporary anchorage in maxillary bone for orthodontic reasons (Triaca et al. 1992; Block & Hoffmann 1995; Wehrbein et al. 1996). Both the mid-sagittal (Triaca et al. 1992; Wehrbein et al.

1996) and paramedian (Bernhart et al. 2000, 2001) regions of the hard palate have been proposed for this kind of implant placement.

Even though palatal implants have been used in orthodontic treatment for more than a decade (Wehrbein et al. 1996), there exists only one prospective study of nine patients demonstrating successful osseointegration and stability in all patients (Wehrbein et al. 1999). Moreover, Bantleon et al. (2002) published a subjective report of 40 Orthosystem® palatal implants and indicated a 92% early survival rate of osseointegration and loading. So far, there is only one scientific report on the success rate of loaded palatal implants ($n = 4$) that were removed after completion of the orthodontic treatment (Wehrbein et al. 1998). Results on any larger number of palatal implants have not been published.

The aim of the present prospective study was to assess the rates of osseointegration as well as the survival rates of loaded palatal implants.

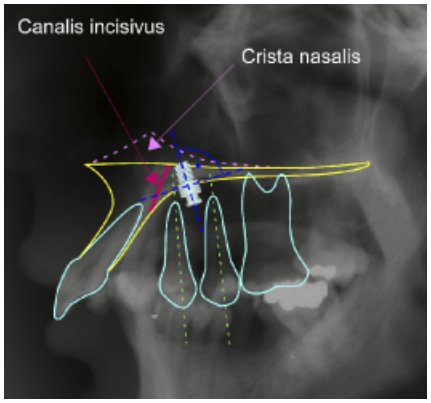

Fig. 1. Most implants are clinically stable when their entry point into the cortical bone is between the anterior-posterior level of the maxillary first and second premolars – perpendicular to the palatal surface.

Material and methods

Seventy-one consecutively admitted patients (56 females, 15 males) (Table 1) receiving the first generation of Orthosystem® palatal implants (Straumann AG, Basel, Switzerland) for orthodontic treatment purposes from March 1999 to November 2006 were included in this prospective study.

The orthodontic indication for implant placement was established according to the required anchorage situation in order to achieve the intended treatment goal. Before placing palatal implants, the vertical bone volume along the palatal suture was assessed in lateral cephalograms (Fig. 1) (Wehrbein et al. 1999). Only in one case of reduced palatal bone height and an impacted upper canine, CT-scans were performed to evaluate possible insertion sites (Bernhart et al. 2000).

All endosseous implants were placed by the same surgeon (R.M.) according to the Straumann® guidelines for respective palatal implants. After injecting a local anesthesia, the palatal mucosa was removed with a punch and an elevator. The cortical bone was marked in the center of the intended implant site with a round drill, the hole for accommodating the implant was drilled by the use of spiral drills (2.2 and 2.8 mm) and the shoulder was prepared with the ortho-profile drill. The self-tapping implant was inserted by hand with a ratchet. In growing patients the palatal implants were inserted in paramedian regions to avoid possible developmental disturbances of the palatal suture (Glatzmaier et al. 1995; Wehrbein et al. 1996; Asscherickx et al. 2005) (Table 1). Based on stability criteria (Buser et al. 1990), all implants that were primary stable after installation were considered for further evaluation. The non-stable implants were removed and palatal implants were, again, inserted at a later date. However, such non-stable but replaced implants were eliminated from further evaluation.

After the healing period, an alginate impression of the implant and maxillary dentition was taken in order to obtain a master cast for designing the supraconstruction, including the orthodontic mechanics. This customized construction was fixed on the abutment in a rotationally stable manner using the internal hexagon of the ortho-cap. The orthodontic mechanical forces either affected the implant directly (active movement of the first molars by the use of 0.018 × 0.025 in. stainless steel sectional wires) or indirectly via the stabilized molars (0.021 × 0.025 in. stainless sectional wires) (Männchen 1999) (Fig. 2).

All implants used in these patients were of the same type: single-unit self-tapping

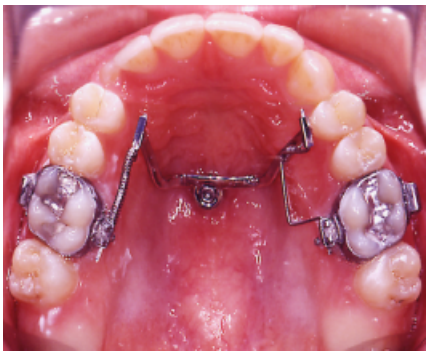

Fig. 2. Supraconstruction consisting of a yoke shaped palatal bar made of 0.36 × 0.72 in. heat-treatable Remaloy (Dentauraum Inc., Ispringen, Germany) stainless with 4.5 mm 0.022 × 0.28 in. rectangular tubes[1] at each end and 0.22″ Damon (Ormco Cooperation, Glendora, CA, USA) brackets welded to the palatal aspect of the molar bands. Tubes and brackets are interconnected by sectional wires. (Männchen 1999).

Table 1. **Frequency distribution of mean age (± SD), sex, implantation site and *healing time* before orthodontic loading for installed implants**

Implant dimension (mm)	*N*	Mean age ± SD	Sex		Implantation site		Mean healing time in weeks ± SD (before orthodontic loading/failure)	
			Male	Female	Median	Paramedian		
Length: 4 Diameter: 3.3	18*	26-1 ± 10-6 median: 26-7	3	15*	4	14*	12.5 ± 3.7	Minimum: 2 Maximum: 20
Length: 4 Diameter: 4	10	23-10 ± 11-5 median: 20-9	1	9	1	9	12.2 ± 2.1	Minimum: 8 Maximum: 15
Length: 6 Diameter: 3.3	42	20-9 ± 10-6 median: 16-5	10	32	5	37	12.9 ± 4.1	Minimum: 3 Maximum: 25
	70	22-6 ± 10-8 median: 17-6	14	56	10	60	12.7 ± 3.8	Minimum: 2 Maximum: 25

*Three out of 70 (4.3 %) installed implants did not successfully osseointegrate.

made of pure titanium with a length of 4 or 6 mm, a diameter of 3.3 or 4 mm, grit-blasted and acid-etched intraosseous surface and a highly polished neck of 2.5 mm (Orthosystem®) (Table 1).

After completion of the orthodontic treatment the palatal implants were removed using a standard trephine of 5.5 mm.

Osseointegration was defined as *successful* when at the time of taking an alginate impression for the supraconstruction, the implant showed absence of mobility and absence of persistent subjective complains (Buser et al. 1990).

The *loading time* was calculated based on the time period between insertion of the supraconstruction and its removal after achieving the intended anchorage needed or the end of November 2006, respectively, if the implant was still in use.

The *success rate* was calculated for patients with *removal of the supraconstruction* on the basis of absence of mobility throughout the entire loading time.

Statistical analysis

Descriptive statistics for all clinical parameters were performed after grouping the implants into three groups: all implants inserted, successfully osseointegrated implants and implants with completion of the intended orthodontic anchorage purposes.

Results

All implants inserted

Initially 71 consecutively admitted patients were recruited for this study (15 males and 56 females). One male person could not be included into the study due to smoking abuse and severe wound healing disorders after a molar extraction. Out of the 70 patients included, two implants in two patients had to be removed 10 and 19 days after installation due to inadequate primary stability. These were replaced in a slightly different location after a healing period of 4 months. Osseointegration thereafter was successful. Nevertheless, these two implants are interpreted as failure and hence are not considered for further evaluation.

Only one or 1.5% out of the 68 primary stable palatal implants did not successfully osseointegrate and was lost before loading. This 4 mm in length and 3.3 mm in diameter implant was lost spontaneously approximately 2 months after implant insertion (Table 1). During the whole healing period, this patient complained about pain in the incisal region. The overall survival rate of osseointegration of the 68 implants was 98.5%.

Successful osseointegration

In all 67 patients (mean age 22 years 6 months ± 10 years and 9 months) with successfully osseointegrated palatal implants that were clinically stable after a mean healing time of 12.7 (SD: 3.9) weeks (Table 1), an alginate impression was taken in order to obtain a master cast for designing the individualized, rotationally stable supraconstruction. After installation of this, 25 implants or 37.3% were loaded actively, 29 implants or 43.3% were used for passive stabilization and 13 implants (19.4%) were used for both purposes, respectively.

By November 2006 and after a mean loading time of 18.8 months, all but one or 98.5% of the 67 osseointegrated palatal implants remained stable under orthodontic loading.

Implants at the removal of the supraconstruction (success rate)

By the time of re-evaluation, 20 Orthosystem® implants were still *in situ* and under orthodontic loading. In 47 patients (mean age 23 years 4 month ± 10 years 3 month), the supraconstruction had been removed due to completion of the orthodontic anchorage needed or implant failure after successful osseointegration (Table 3). One patient refused the removal of the palatal implant after treatment.

The overall survival rate in this patient cohort ($n = 70$) was 94.3%. It has to be kept in mind, however, that 20 patients still were in orthodontic treatment at the completion of the study.

By analyzing the 46 implants successfully loaded and removed Orthosystem® palatal implants after completion of orthodontic therapy only, the overall success rate was 92% for a mean loading time of 21.4 months (two lost implants: one in the early healing phase, one under loading).

Discussion

The purpose of this study was to assess the survival rate of osseointegration and loading of palatal implant and the success rate of palatal implants with removal of the supraconstruction after completion of the intended orthodontic treatment.

Despite the small dimensions, orthodontic implant anchoring devices must maintain positional stability under orthodontic loading in order to serve as absolute anchorage. Therefore, osseointegration is a prerequisite. Histological examination of explanted human palatal orthodontic implant bone specimens revealed that osseointegration is maintained during long-term orthodontic loading under clinical conditions (Wehrbein et al. 1998). This suggests that an adequate anchorage to withstand orthodontic loading can also be achieved with these small implants.

In some cases, there may be a premature loss of the implant before orthodontic loading. This loss may be attributed to the lack of adequate primary stability. Insufficient primary stability causes connective tissue encapsulation and the possible premature loss of the implant (Friberg et al. 1991; Lioubavina-Hack et al. 2006).

There are substantial differences between orthodontic forces and occlusal loading applied to implants. Orthodontic forces are continuous and horizontal or oblique. Occlusal loads, in contrast, are discontinuous and expected to be mainly along the long axis of the implants/teeth. Therefore, the effect of orthodontic loading to the adjacent bone of the implant is of great interest. The applied forces should not have a negative impact on the peri-implant bone and impair the long-term prognosis of the implant. In an experimental study, oral implants were inserted in monkeys and subjected to well-defined continuous loading (Melsen & Lang 2001). None of the implants had lost osseointegration after 11 weeks of loading, but loading significantly influenced the turnover of the alveolar bone in the vicinity of the implants. When the strain exceeded a threshold, the remodeling of the bone resulted in a net loss. It may be speculated that the reason for the one and only failure of a successfully osseointegrated implant in this study could be attributed to a unilateral heavy and excessive orthodontic loading.

Most of the implant studies reporting on survival and failure rates of implants, deal with surrogate biological endpoints (Karoussis et al. 2004) or technical failures

Table 2. **Frequency distribution of mean age (± SD), sex, implantation site, type of load and *mean loading time* for successfully loaded implants**

Implant dimension (mm)	*N*	Mean Age ± SD	Sex		Implantation site		Type of Loading			Mean loading time of the supraconstruction in month ± SD	
			Male	Female	Median	Paramedian	Active	Passive	Both		
Length: 4 Diameter: 3.3 mm	16	26-7 ± 10-6 median: 27-0	3	13*	3	13*	8*	6	2	21 ± 11.1	Minimum: 5 Maximum: 50
Length: 4 Diameter: 4	9	24-6 ± 11-9 median: 22-7	1	8	1	8	5	1	3	23 ± 15.3	Minimum: 1 Maximum: 56
Length: 6 Diameter: 3.3	42	20-9 ± 10-6 median: 16-5	10	32	5	37	12	22	8	17.1 ± 9.31	Minimum: 1 Maximum: 37
	67	22-8 ± 10-6 median: 17-6	14	53	9	58	25	29	13	18.8 ± 10.7	Minimum: 1 Maximum: 56

*One implant of 4 mm diameter and 3.3 mm length in a female patient lost its stability after a 5 month unilateral loading time and had to be removed.
One or 1.5% of 67 successfully osseointegrated implants did not remain stable under loading.

Table 3. **Frequency distribution of mean age (± SD), sex, implantation site, type of load and mean *loading time* for successfully loaded implants with removal of the supraconstruction due to completion of the orthodontic anchorage need or implant failure**

Implant dimension (mm)	*N*	Mean Age ± SD	Sex		Implantation site		Type of Loading			Mean loading time of the supraconstruction in months ± SD	
			Male	Female	Median	Paramedian	Active	Passive	Both		
Length: 4 Diameter: 3.3	13*	25-4 ± 10-3 median: 24-1	3	10*	4	9*	7*	5	1	23.9 ± 10.1	Minimum: 5 Maximum: 50
Length: 4 Diameter: 4	7	23-8 ± 13-2 median: 18-11	1	6	1	6	2	4	1	22.4 ± 6.1	Minimum: 16 Maximum: 31
Length: 6 Diameter: 3.3	27	22-3 ± 9-8 median: 17-7	6	21	3	24	5	16	6	20.6 ± 7.6	Minimum: 9 Maximum: 37
	47	23-4 ± 10-3 median: 18-11	10	37	8	39	14	25	8	21.4 ± 8.4	Minimum: 5 Maximum: 50

*One implant of 4 mm diameter and 3.3 mm length in a female patient lost its stability after a 5 month unilateral loading time and had to be removed.
20 of 67 successfully loaded implants are still in use and therefore not considered for this evaluation.
One or 2.1% of 47 removed implants did not remain stable under loading.

(Pjetursson et al. 2007). But there are substantial differences between a success of prosthetic implants and temporary anchorage devices. As prosthetic implants have an uncertain clinical endpoint (death of the patient), a clinical success starts with the installation of the prosthetic unit.

Palatal implants, however, are temporary anchorage devices and usually removed after use. As a consequence, their loading time is shorter and defined by the pre-existing treatment plan and the end of the need for additional anchorage. Success is not achieved by the installation and loading over time, however, but by the removal of the supraconstruction. Therefore, the comparison of survival and success rates of prosthetic dental implants with those of temporary anchorage devices is limited.

Concerning these limitations, just the 'early failures' during the healing period can be directly compared with prosthetic implants. In the present study, one implant did not fulfill the criterion of success at the completion of the healing period. This low failure rate is consistent with results reported for short epithetic implants (Bernhart et al. 2001) and prosthetic implants (Buser et al. 1997).

The long-term success rates for dental implants are generally indicated between 88% and 96% after 6–14 years (Berglundh et al. 2002).

This report documented a successful *loading* rate of 98.5% after approximately 19 months (Table 2) of orthodontic use of palatal implants. This rate is higher than the 90% success rate of 20 similar and early loaded Orthosystem® palatal implants (Crismani et al. 2006) and for 21 short epithetic implants with a machined surface loaded for approximately 23 months (84.8%) (Bernhart et al. 2001). There is one report of 40 Orthosystem® palatal implants indicating a 92% early success rate of osseointegration and loading (Bantleon et al. 2002).

As there is no existing study analyzing the successfully loaded implants with completion of the orthodontic treatment, the present study is the first analyzing 46 successfully loaded and removed Orthosystem® palatal implants and reporting a success rate of 92% (two implants lost: one during early healing phase, one under loading, Table 3).

During the last decade, an increasing number of articles have been published on the use of micro-implants or mini-screws (Kanomi 1997; Costa et al. 1998). This type of anchorage is not suitable for the application of anchorage moments. Only simple forces may be applied demanding a perfect positioning in relation to the desired tooth-movement. Although the palatal implants used in this study had slightly smaller dimensions than traditional dental implants, it could clinically be shown that they are able not only to resist forces but also moments in the horizontal dimension. This shows their superiority to the micro-implants in the maxilla.

In conclusion, orthodontic palatal implants, such as the Orthosystem® (Straumann AG), with a rough surface and rotation resistant supraconstruction provide a new dimension in orthodontic anchorage as they reduce the need for patient

compliance and offer increased clinical flexibility and effectiveness. These temporary anchorage devices are providing reliable absolute orthodontic anchorage and hence, are considered to be superior to any orthodontic tooth-borne anchorage device. Nevertheless, it must be kept in mind that this kind of skeletal anchorage has no skeletal growth modification potential and must therefore be carefully considered vs. extraoral or functional appliances in growing individuals.

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