A Retrospective Comparison of Implants in the Pterygomaxillary Region: Implant Placement with Two-Stage, Single-Stage, and Guided Surgery Protocols

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Purpose: *Implants placed into the pterygomaxillary region allow for increased posterior support and a full complement of teeth without the need for distal cantilevers. With advancements in research and technology, implant delivery has evolved from the traditional two-stage procedure to immediate loading freehand and guided surgical template protocols. The purpose of this retrospective study is to determine if there is a significant difference in implant survival rates between these protocols.* ***Materials and Methods:*** *All pterygomaxillary implants placed in a single private practice from September 1985 to July 2011 were categorized into three separate classifications (two-stage freehand, single-stage freehand, or single-stage guided) by retrospective chart review. Life tables were constructed to determine the cumulative survival rates (CSR), and ANOVA was used to identify statistical significance.* ***Results:*** *A total of 981 patients comprising 371 males and 610 females were included in the study. Of all pterygomaxillary implants, 1,460 of 1,608 implants osseointegrated for a CSR of 90.80%. Seven hundred nine of the 825 two-stage, 624 of the 647 single-stage, and 127 of the 136 guided surgery implants osseointegrated for CSRs of 85.94%, 96.45%, and 93.38%, respectively. The comparison between two-stage and single-stage protocols was statistically significant, (*$P < .05$*) while the difference between single-stage guided versus freehand protocols was found to be statistically insignificant (*$P > .05$*).* ***Conclusion:*** *The results from this retrospective study reinforce that immediate loading of pterygomaxillary implants with a provisional prosthesis is beneficial to both doctor and patient. The lower CSR for the guided surgery protocol compared with the single-stage freehand procedure is statistically insignificant, suggesting guided surgery is still a viable and recommended option for qualified patients.* Int J Oral Maxillofac Implants 2013;28:184–189. doi: 10.11607/jomi.2693

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The posterior maxilla is considered the most difficult and problematic intraoral area for treatment with osseointegrated implants.[1] According to a 1993 report by Schnitman et al,[2] osseointegration was the least successful in the posterior maxilla (72%). The location of the antrum, deficient bone quality, bone quantity, surgical access, and biomechanics (greater masticatory forces) make it a challenge to restore dentition in this region.[3] However, implants delivered into the dense cortical bone of the pterygomaxillary region that effectively osseointegrate have been found to provide adequate support in the posterior maxilla[4] and eliminate procedures such as sinus augmentations, supplemental bone grafts, posterior cantilevers,[5] and the use of a large number of implants.[6]

Since its inception, pterygomaxillary implant placement has evolved from a two-stage freehand delivery to a single-stage (ie, immediate loading) freehand protocol. With the advent of computer-aided design/computer-assisted manufacture (CAD/CAM) and medical imaging technologies, implant delivery has been further revolutionized. Prosthetically driven surgical

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templates are now used to plan surgery and provide pinpoint placement into the dense cortical bone of the pterygomaxillary complex.

The conventional two-stage treatment approach was first published by Brånemark et al in 1969.[7,8] In the first stage, the mucosa is reflected, implants are delivered, a cover screw is placed, and the surgical site is sutured. After approximately 6 months, stage-two surgery is performed and transmucosal abutments are connected.[3] This protocol initially did not support the delivery of implants into the pterygomaxillary complex. Yet, after further research into the pterygoid region,[4,9] Brånemark noted the possibility of high osseointegration rates in this area.

The single-stage freehand protocol combines the implant placement and abutment connection surgical procedures into a single procedure where a screw-retained all-acrylic provisional prosthesis is delivered. This protocol provides many advantages to both the patient and practitioner, as the ability to place implants and have fixed prostheses in the same day[10–12] offers esthetics, comfort, and function throughout the healing phase. Further, the provisional prosthesis protects the sutured mucosal tissues.[13] In patients treated with pterygomaxillary implants, the freehand protocol requires full flap reflection to ensure accurate identification of the receptor site.

Traditionally, periapical and panoramic radiographs are used to plan implant treatment. According to Kraut,[14] these types of radiographs do not provide a definitive strategy for the delivery of implants. With the introduction of CAD/CAM (NobelGuide or NobelClinician, Nobel Biocare) systems[15–17] and application of cone beam computed tomopgraphy (CBCT) scans, 3D image-derived features can be rotated on any axis for multiple perspectives.[16] Virtual implants and abutments can be inserted into the 3D image for predetermined implant placement in the best receptor site.[17] The patient's existing removable denture is then cloned to create a surgical template. Thus, the centric and vertical positions of the prosthesis will mimic the original denture.[16] This specific guided surgery protocol with the prefabricated surgical template is intended to be a flapless protocol with no suturing required.

The purpose of this retrospective study is to examine all pterygomaxillary implants delivered in a single private practice (PI Dental Center, Fort Washington, PA) and examine if there is a statistically significant difference in the cumulative implant survival rates between the two-stage freehand, single-stage freehand, and single-stage guided surgery protocols. It is hypothesized that the guided surgery protocols will possess the highest implant survival rate due to the precise planning of implant placement available with CAD/CAM technology, thus proving that guided surgery technology is the best option for implant delivery.

MATERIALS AND METHODS

Patients involved in this study presented with either complete edentulism or a periodontally compromised dentition that was considered unrestorable. A comprehensive treatment plan consisting of one of the three protocols (two-stage, single-stage, or guided surgery) was formulated. To qualify for guided surgery, patients had to be completely edentulous prior to implant placement for the use of the surgical template. In freehand procedures, patients who presented with failing teeth had them extracted the day of implant surgery. Patients rarely presented with intact third molars; thus, the pterygomaxillary receptor site was a completely edentulous site. In addition, all patients who had implant reconstruction performed at the private practice executed consent forms that state their treatment may be included in prospective or retrospective scientific research.

A retrospective chart review was performed for all patients with pterygomaxillary implants placed between September 1985 through July 2011. All implants were classified into three different categories: two-stage freehand, single-stage freehand or single-stage guided.

Two-Stage Freehand Category

The two-stage freehand protocol for pterygomaxillary implants was introduced clinically in 1985. Inclusion criteria for a two-stage characterization included placement of cover screws on the pterygomaxillary implants during the first stage of surgery. This was confirmed upon observation of postoperative panoramic radiographs and clinical notes (Dentrix Dental Systems, Henry Schein) and implant tracking software (Implant Tracking Systems). Further verification was provided by the presence of stage-two clinical notes, which succeeded the average 6- to 8-month healing time.

Single-Stage Freehand Category

The clinical introduction of a single-stage freehand pterygomaxillary implant delivery occurred in 2000. Inclusion criteria for a single-stage categorization were the immediate connection of transmucosal abutments (Brånemark Standard or Multi-Unit, Nobel Biocare) to the pterygomaxillary implants and attachment of the provisional all-acrylic resin screw-retained prosthesis. This was confirmed by postoperative panoramic radiographs, clinical notes, and implant tracking software. Careful consideration was taken into account for the type of abutment placed on the implants. If a healing abutment was used, the implant was classified as two-stage, not single-stage.

Single-Stage Guided Surgery Category

Pterygomaxillary implant placement with a single-stage guided surgery approach arose in 2004. Inclusion

Table 1 Frequency Distribution of Implants Placed in the Pterygomaxillary Region

Implant type/size	Amount (n = 1,608)
3.75 × 7 mm	6
3.75 × 8.5 mm	3
3.75 × 10 mm	25
3.75 × 11.5 mm MkIII Groovy*	1
3.75 × 13 mm	67
3.75 × 13 mm MkII	1
3.75 × 13 mm MkIII Groovy*	5
3.75 × 15 mm	327
3.75 × 15 mm Astra Tech	2
3.75 × 15 mm MkII	3
3.75 × 15 mm MkIII Groovy*	37
3.75 × 15 mm Sterngold ImplaMed	2
3.75 × 17 mm Astra Tech	3
3.75 × 18 mm	57
3.75 × 18 mm MkIII Groovy*	7
3.75 × 19 mm Astra Tech	2
3.75 × 20 mm	51
4 × 7 mm	4
4 × 10 mm	13
4 × 10 mm Ebon	2
4 × 10 mm MkIV Groovy*	7
4 × 13 mm	8
4 × 13 mm MkIV	11
4 × 13 mm MkIV Groovy*	29
4 × 15 mm	70
4 × 15 mm Ebon	6
4 × 15 mm MkIII Groovy*	38
4 × 15 mm MkIV Groovy*	390
4 × 18 mm	30
4 × 18 mm Ebon	4
4 × 18 mm MkIII Groovy*	16
4 × 18 mm MkIV	7
4 × 18 mm MkIV Groovy*	367
5 × 6 mm	1
5 × 10 mm	2
5 × 11.5 mm MkII	1
5 × 12mm	3

All implants are NobelBiocare with the exception of Sterngold ImplaMed and Astra Tech
*Phosphate enriched titanium oxide–surface implant (TiUnite).[18]

criteria were the use of a CBCT scan (iCAT; Imaging Sciences International) and a stereolithic surgical template (NobelGuide or NobelClinician) for the placement of implants. This was verified with the evaluation of clinical notes, implant tracking software, and cross reference with patients in the guided surgery database.

Implant cumulative survival rates (CSRs) were calculated for each protocol grouping. Single-stage and guided protocols were combined to provide a survival rate for all immediately loaded implants. These data were used to compare the difference in CSRs between two-stage and single-stage procedures. Multivariate analysis of variance (MANOVA) was used to compare the significance in the CSRs between protocol groupings. Exclusion criteria for this study were patients who did not receive a pterygomaxillary implant during the time frame of the study.

RESULTS

Nine hundred eighty-one patients (371 males, 610 females) with a mean age of 58 years (range, 14 to 90 years) met the inclusion criteria. Of all the pterygomaxillary implants placed since 1985, 1,460 of the 1,608 implants successfully osseointegrated, resulting in a CSR of 90.8%. Nine hundred of 1,000 (90.0%) implants placed in females survived, while 560 of 608 (92.1%) implants in males survived. In regard to implant surface, 603 of the 710 (84.9%) machined-surfaced implants and 857 of the 898 (95.4%) titanium oxide–surfaced implants (TiUnite, Nobel Biocare) remained in function. A distribution of the implants placed is shown in Table 1.

When broken down into their respective protocols, the two-stage delivery had 709 of the 825 (85.94%) pterygomaxillary implants osseointegrate (Table 2). The single stage freehand protocol had a survival rate of 96.45% (624 of 647, Table 3). In the single-stage guided protocol, 127 of the 136 (93.38%) pterygomaxillary implants were successfully osseointegrated (Table 4). The combined immediate load (freehand and guided) CSR equated to 95.91% (751 of 783, Table 5).

When comparing the CSRs, those of all single-stage pterygomaxillary implants (freehand and guided) were approximately 10% higher (95.91%) than two-stage implants (85.94%). This difference was found to be statistically significant (MANOVA; $P < .05$). The single-stage guided CSR was 3% lower (93.38%) than the single-stage freehand protocol (96.45%). The difference was statistically insignificant (MANOVA; $P > .05$).

Within the years of 2000 to 2004, there was a clinical phase that demonstrated a gradual integration of the single-stage freehand protocol with the traditional two-stage practices. A majority of cases during this

Table 2 CSRs for Two-Stage Freehand Protocol

Period	No. of implants	No. of failures	Survival rate (%)	CSR (%)
0–3 mo	825	6	99.27	99.27
3–6 mo	818	42	94.87	94.18
6–9 mo	776	35	95.49	89.94
9–12 mo	739	9	98.78	88.85
1 y	730	10	98.63	87.64
2 y	718	0	100.0	87.64
3 y	715	0	100.0	87.64
4 y	713	4	99.44	87.15
5 y	703	2	99.72	86.91
6 y	691	5	99.28	86.30
7 y	673	2	99.70	86.06
8 y	660	0	100.0	86.06
9 y	626	1	99.84	85.94
10+ y	562	0	100.0	85.94

Table 3 CSRs for Single-Stage Freehand Protocol

Period	No. of implants	No. of failures	Survival rate (%)	CSR (%)
0–3 mo	647	3	99.54	99.54
3–6 mo	644	12	98.12	97.68
6–9 mo	628	1	99.84	97.53
9–12 mo	617	2	99.67	96.60
1 y	600	4	99.31	96.45
2 y	530	1	99.81	96.45
3 y	485	0	100.0	96.45
4 y	422	0	100.0	96.45
5 y	341	0	100.0	96.45
6 y	217	0	100.0	96.45
7 y	116	0	100.0	96.45
8 y	45	0	100.0	96.45
9 y	12	0	100.0	96.45
10+ y	5	0	100.0	96.45

time used a single-stage delivery in the anterior yet still used the two-stage approach for pterygomaxillary implants. It was not until October of 2004 that the single-stage protocol was employed as the treatment standard for all implants in this clinical practice.

Table 4 CSRs for Single-Stage Guided Protocol

Period	No. of implants	No. of failures	Survival rate (%)	CSR (%)
0–3 mo	136	3	97.69	97.79
3–6 mo	133	4	96.80	94.85
6–9 mo	127	1	99.16	94.12
9–12 mo	120	0	100.0	94.12
1 y	118	0	100.0	94.12
2 y	107	0	100.0	94.12
3 y	100	1	98.81	93.38
4 y	79	0	100.0	93.38
5 y	37	0	100.0	93.38
6 y	15	0	100.0	93.38
7 y	8	0	100.0	93.38

DISCUSSION

Posterior maxillary support for fixed prosthesis anchorage can be provided by placing implants in the dense cortical bone of the medial and lateral pterygoid plates using various methods of delivery. Previous reports[4,9,16,19–22] have demonstrated the high success of such procedures but do not adequately compare the protocols available for implant delivery. CAD/CAM technology has offered a contemporary twist that challenges the traditional freehand practices. Thus, significant data is needed to determine which protocol most benefits the patient and practitioner.

Prior research has demonstrated the advantages of immediate loading, especially in the anterior.[10,11,23–31] This study found similar results in the posterior, as pterygomaxillary implants that were immediately loaded (freehand and guided) had a CSR 10% higher (see Tables 2 and 5) than the traditional two-stage Brånemark protocol, a statistically significant difference. Multiple factors can account for the higher rate of osseointegration for immediate loading. For example, immediately delivering a prosthesis allows for a splinting effect between all implants, thereby distributing the biomechanical and functional loads. In addition, the introduction of the Brånemark System TiUnite implant has played a critical role in single stage implant survival rate. In a 2005 study by Balshi et al,[20] the TiUnite implant had a CSR 8% higher when compared to a machine-surfaced implant in the pterygomaxillary region.

CAD/CAM technology, along with use of a surgical template, allows a prosthodontist to identify the best implant/bone interface for maximum stabilization of the provisional prosthesis prior to surgery.[14,16] Due to this ability, the authors hypothesized the guided surgery protocol would produce a higher cumulative survival rate in the pterygomaxillary region than

Table 5 CSRs of All Single-Stage (Immediately Loaded) Implants (Freehand + Guided)

Period	No. of implants	No. of failures	Survival rate (%)	CSR (%)
0–3 mo	783	6	99.22	99.23
3–6 mo	777	16	97.89	97.19
6–9 mo	755	2	99.73	96.93
9–12 mo	737	2	99.72	96.68
1 y	718	4	99.42	96.17
2 y	637	1	99.84	96.04
3 y	585	1	99.82	95.91
4 y	501	0	100.0	95.91
5 y	378	0	100.0	95.91
6 y	232	0	100.0	95.91
7 y	124	0	100.0	95.91
8 y	45	0	100.0	95.91
9 y	12	0	100.0	95.91
10+ y	5	0	100.0	95.91

freehand practices. This study found that the guided surgery protocol had a CSR 3% lower (93.38%, see Table 4) than the freehand single-stage protocol (96.45%, see Table 3) but the difference was statistically insignificant. The insignificance may be the result of the number of implants placed with the guided surgery protocol (136) being much lower compared with the high number of single-stage freehand implants (647) placed.

There are still surgical advantages to both the single-stage guided surgery and single-stage freehand approaches. The freehand technique allows the ability to adjust or re-angle the osteotomy site based on what the surgeon encounters. In addition, the freehand technique offers better firsthand visualization of the surgical site and the opportunity to alter bone or soft tissue while the mucosa is reflected. Some advantages for guided surgery include the increased accuracy of implant placement based on the location of anatomical structures, predetermined osteotomy sites, preparation of a highly precise circular osteotomy, and prefabrication of a laboratory processed all-acrylic provisional prosthesis. Further, flapless implant placement reduces postoperative swelling and discomfort.

The authors believe CAD/CAM technology and surgical templates are the preeminent implant protocol for both patient and the prosthodontist when delivering a fixed provisional prosthesis at the time of implant placement. However, because of the short time frame of guided surgery (7 years) this study is a preliminary report. Long-term follow-up studies with significant guided surgery implant pools and high CSRs are necessary to prove its superiority over traditional freehand procedures.

CONCLUSIONS

Pterygomaxillary implants have shown to provide adequate stability in the posterior region despite studies reflecting upon poor ergonomics and increased occlusal forces. The single-stage freehand protocol has a statistically significant higher CSR when compared with the traditional two-stage Brånemark protocol. The difference between the guided surgery CSRand that of single-stage freehand protocols was proven to be statistically insignificant. This suggests that even though guided surgery has a lower CSR than single-stage freehand, it can be a valuable alternative for both the patient and clinical team.

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