Maxillary Implant-Supported Fixed Prosthesis: A Survey of Reviews and Key Variables for Treatment Planning

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Purpose: *This review was conducted to provide information to support the establishment of clinical guidelines for the treatment of maxillary edentulism using implant-supported fixed dental prostheses.* ***Materials and Methods:*** *Initial efforts were directed toward a systematic review with a defined PICO question: "For maxillary edentulous patients with dental implants treated using a fixed prosthesis, what is the impact of prosthesis design on prosthesis survival and complications?" Following a title search of more than 3,000 titles identified by electronic search of PubMed, 180 articles were identified that addressed the clinical evaluation of maxillary dental implant prostheses. The broad methodologic heterogeneity and clinical variation among reports precluded this approach for a systematic review. The information was extracted using a standardized extraction table by two pairs of investigators, and the reported outcomes were then summarized according to reported outcomes for implant prostheses supported by four, six, or eight implants using unitary or segmented prostheses.* ***Results:*** *This review indicated that high prosthetic survival is observed using all approaches. The advantages of using fewer implants and a unitary prosthesis are revealed in the surgical phases, and complications commonly involve the fracture or detachment of acrylic teeth and reduced access for proper oral hygiene and related biologic complications. Using six implants typically involved grafting of posterior regions with advantages of reduced cantilevers and redundancy of implant support. Reduced prosthesis survival in these cases was associated with poor implant distribution. Segmented prostheses supported by six or more implants offered greater prosthetic survival, perhaps due to posterior implant placement. Advantages of a segmented prosthesis included pragmatic issues of accommodating divergent implants, attaining passive fit, combining prosthetic materials, and relative simplicity of repair.* ***Conclusion:*** *The existing literature demonstrated that maxillary edentulism may be treated successfully using alternative approaches involving four, six, or more implants. The procedural diagnostics, treatment, and maintenance for these different approaches all require advanced knowledge and careful communication among the therapeutic team. The prosthetic therapeutic success requires maintenance, repair, and possible multiple replacements within the patient's lifetime.* Int J Oral Maxillofac Implants 2016;31(suppl):s192–s197. doi: 10.11607/jomi.16suppl.g5.3

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The restoration of the edentulous maxilla using dental implants is often challenged by multiple factors that influence clinical decision-making. Recent systematic reviews suggest that the overall implant survival and the extent of prosthetic complications differ. In fact, compared with implant survival rates of approximately 90% to 95%, the complication rates for maxillary implant fixed prostheses are higher.[1,2] The possible scope of treatment was revealed by Att et al,[1] who included implant rehabilitations without bone augmentation (implants > 10 mm, tilted implants, or zygoma implants) and implant rehabilitation with bone augmentation (sinus floor elevation and interpositional bone grafting). There was little data reported for prosthesis survival, but where reported, implant-supported fixed prosthesis (ISFP) survival in the maxilla was high. Quantification of complications was not achieved, however. This has been borne out by other systematic reviews.[1–3]

The edentulous maxilla presents several challenges for implant therapy. Principal among them is relatively low bone quality as compared with the edentulous mandible. Bone volume also varies remarkably throughout the maxilla and among individuals. Solutions to the bone volume problems fall into three categories: *(1)* grafting, *(2)* the use of shorter implants with enhanced surface topographies, and *(3)* the use of tilted implants or extra-alveolar implants (including pterygoid and zygomatic implants). In this context, the primary outcome for this specific report is a successful, stable, and predictable prosthetic restoration that makes use of whatever implant configuration is placed, with patient-oriented positive outcomes associated with esthetics, phonetics, function, comfort, lip support, ease of hygiene, and patient-perceived value for the treatment outcome.

Major maxillary bone grafting procedures may solve some of the clinical limitations and enable the otherwise unavailable implant solutions to patients. However, implant survival in grafted bone has been repeatedly demonstrated to be lower than implant survival in native bone.[4–8] Regarding short implants, several systematic reviews reveal high success.[9–13] Surface roughness contributes to improved implant survival in the lower-density bone of the maxilla, and several retrospective studies demonstrate higher survival of rough versus machined implants placed in the edentulous maxilla.[14,15] Zygomatic and pterygoid implants offer high implant survival[16–18]; however, complications associated with zygomatic implants are reportedly higher than for conventional implants. It is important to recognize that challenges and complications accompany this restoration and include unhygienic contours with palatal position of the implants, phonetic challenges with palatal contours, and vertical space limitations where the implants pass into the oral cavity. Additional training is required for appropriate utilization of these extra-alveolar implant types. Thus, the approaches offered to the patient for treatment of the edentulous maxilla using implant-supported fixed prostheses are dependent on the initial clinical situation of the edentulous maxilla.

Secondarily, the clinical team must consider either a grafting approach to provision of sufficient implants or a nongrafting approach utilizing short, angled, or extra-alveolar implants. Finally, once the patient has selected one of the presented possible treatment options, the clinical and laboratory teams must have the combined skillset to provide it safely and predictably. Another surgical variable presented in the literature is time of loading for dental implants. Suggested is an incrementally higher risk for immediate loading of implants in the edentulous maxilla compared with immediate loading of implants in the edentulous mandible.[19]

The original intent of this review was to explore the restorative options available for treatment of the edentulous maxilla using an implant-supported fixed prosthesis with guidance from existing clinical studies and published systematic reviews. Our initial efforts explored the potential of a systematic review to determine the extent of knowledge regarding the PICO question, "For maxillary edentulous patients with dental implants treated using a fixed prosthesis, what is the impact of prosthesis design on prosthesis survival and complications?" Following a title search of more than 3,000 titles identified by an electronic search of PubMed, 180 articles were found that addressed the clinical evaluation of maxillary dental implant prostheses. It became apparent that the broad methodologic heterogeneity and clinical variation among reports precluded this approach for a systematic evaluation of the literature. A further limitation in seeking an answer to this question was that the concept of a prosthesis complication has not been fully explored and a definition is lacking. Survival of the prosthesis connotes its use over time without replacement or loss. Complications have included extremes such as mechanical failure requiring replacement to chipping of porcelain veneers or wear of acrylic resin.

Therefore, the intent of this review was to explore the restorative options available for treatment of the edentulous maxilla using an implant-supported fixed prosthesis with guidance from existing clinical studies and published systematic reviews. In seeking to simplify our approach, we focused on the key factors demonstrated in the literature to drive a restorative strategy: the number, distribution, and orientation of implants that have been placed in the maxilla. Secondarily, it was possible to distinguish a difference for greater than six implants and for the provision of a one-piece versus a segmented prosthesis. Differences in the application of a screw-retained versus cement-retained approach were also discussed.

LESS THAN SIX IMPLANTS WITH A ONE-PIECE PROSTHESIS

Brånemark's initial conceptualization of treatment of the edentulous maxilla involved placement of five or six implants in the region of the maxilla anterior to the maxillary sinuses and restoring the patient with a one-piece acrylic-veneered gold prosthesis. The initial 1995 report of Brånemark et al indicated relatively low prosthesis survival that may have been associated with the 80.3% implant survival rate.[20] One prosthesis supported by four implants failed, while six prostheses supported by six implants failed. The use of four tilted implants to support the maxillary implant-supported fixed prosthesis was also proposed[21] using an immediate function protocol. The initial reported cohort of 23 patients demonstrated high implant survival,[22] and a

subsequent 5-year report demonstrated that 93% of 252 patients experienced no implant failures with a 100% prosthesis survival.[23] For 300 maxillary implants in 75 maxillae, similar high success was revealed at the implant level, but no information regarding prosthesis outcome was reported.[24] The use of less than four implants may not be feasible.

However, evidence on the complication rates associated with tilted implants using at least four implants is scarce and inconsistently reported. The technical challenges of this approach include increased difficulty in surgery and overcoming limited anterior/posterior distribution of supporting implants. It is noted that guided surgical approaches may aid in placement of implants to facilitate prosthesis construction and longevity.[25]

Central to choosing to use four implants, implant loss results in failure of the prosthesis. When acrylic veneered metal frameworks are used for restoration, there is a high likelihood of complications. An up to 5-year retrospective study of 34 maxillary prostheses revealed that approximately 20% of patients experienced fracture or detachment of acrylic teeth and nearly 40% experienced hygienic complications.[26] Further, there is little knowledge regarding the prosthetic complications for the monolithic zirconia alternatives. Mechanical risks to the prosthesis may be accentuated with increased cantilever lengths.

The advantages of using fewer (four or five) implants and a one-piece prosthesis include reduced surgical costs to the patient and potentially reduced surgical time, with no prior bone grafting experience necessary. Based on these features of this approach, it may be recommended that this is a complex procedure that should be conducted by an experienced team with a comprehensive knowledge of both the surgical and restorative aspects of care. Additionally, there is a requirement for experienced laboratory support. The risks and benefits of this approach call for a careful examination to consider the use of an implant-retained overdenture as a viable, less complex alternative implant prosthetic protocol.

SIX OR MORE IMPLANTS WITH A ONE-PIECE PROSTHESIS

Treatment using six or more implants may provide for 5 to 10 years of implant survival.[27] The related prosthesis survival for full-arch fixed dental prostheses was also high at 10 years (95% CI 88.5% to 97.9%). The placement of six or more implants distributed anteriorly and posteriorly in the maxilla often involves grafting of the alveolus and or the maxillary sinuses. The prosthesis construction involving more implants can become complex, particularly if malposition of implants is encountered.

The potential complications identified by review of the related literature include those associated with reduced implant survival in grafted bone, screw loosening, and prosthetic complications of acrylic wear and acrylic tooth chipping, as well as chipping of ceramic-veneered prostheses. The advantages of this approach include avoiding cantilevers, incorporating cross-arch stabilization of stress distribution, and redundancy of implant support, which prevents prosthesis loss if a single implant is lost. In a structured review that compared outcomes based on the number of implants per patient,[3] prosthesis survival tended to be lower when fewer than six implants supported the prosthesis from 1 to 10 years (at 5 years 92.6% versus 92.7%, $P = .05$, for < 6 or > 6 implants, respectively). The authors also described an impact on implant distribution; lower prosthesis survival was found when implants were not distributed anteriorly and posteriorly beyond the second premolar.[3]

Based on these observations, the recommendations for treatment include: an experienced team with comprehensive knowledge of surgical/restorative aspects related to this advanced procedure, a detailed presurgical analysis based on prosthetically driven implant position, selection of prosthetic materials based on patient-centered parameters (patient preference, age, esthetic requirement, bruxism, etc), and careful, robust prosthesis design and proper manufacturing technique to preclude chipping or fracture. The restorative process should involve an experienced laboratory and requires careful evaluation and adjustment of the occlusion upon delivery and throughout the periodic recall program.

SIX OR MORE IMPLANTS WITH A SEGMENTED PROSTHESIS

While no studies comparing the number of implants (four, six, or more than six) have been reported for the segmented maxillary implant-supported fixed prostheses, one systematic review suggested that the prosthodontic survival rates were significantly greater for restorations supported by six or more implants compared with those supported by fewer than six implants.[3] The summary data demonstrated no difference in prosthesis survival for one-piece versus segmented prostheses. It was argued that using more implants to achieve implant distribution beyond the first premolar was associated with increased prosthodontic survival ($P < .001$).

Many of the potential complications of the segmented prosthesis reflect those of one-piece prostheses supported by six or more implants. Included are the reduced implant survival in grafted bone, screw loosening and fracture, and prosthetic complications. The key advantage of a segmented prosthesis is that the loss of one implant may not result in loss of the

entire reconstruction. Additional advantages of using a segmented prosthesis for restoration of the edentulous maxilla include the pragmatic issues that address divergent angulation of implants in the anterior versus posterior maxilla, associated simplification of laboratory procedures and attainment of passive fitting prostheses, the use of different prosthetic materials in the anterior and posterior regions, and possibly simpler procedures by using cement-retained prostheses.

The difficulties inherent to this approach are not unique either. The possible need for bone grafting to support additional implants, the need to create complex prosthetic solutions including custom abutments, and related phonetic or esthetic complications have all been reported.

Based on the limited available data and information regarding the segmented restoration on more than six implants, it is recommended that patients be treated by an experienced team with a comprehensive knowledge of surgical/restorative aspects of therapy following a detailed presurgical analysis that leads to prosthesis-directed implant placement. A highly experienced laboratory should be engaged in assisting in the selection of patient-specific materials (based on patient preference, age, function, esthetic requirements, opposing arch status) and the fabrication of a well-designed prosthesis that can avoid chipping or catastrophic failure. The insertion requires verification and adjustment of the occlusion and regular evaluation and maintenance.

PROSTHESIS VARIABLES INFLUENCING OUTCOMES

This review identified two general categories of prosthesis variables that may influence maxillary implant-supported fixed prostheses: *(1)* screw-retained versus cement-retained and *(2)* prosthetic material selection. The results suggest that no prosthesis is yet to be proven free from complications. However, the reasons for catastrophic failure may be attributed to planning, prosthesis design, or execution factors. The main complication influencing the use of screw or cement retention involves screw loosening and fracture versus de-cementation. The difficulties, advantages, and recommendations are enumerated in Table 1. When considering prosthetic material selection, the prominent choices include metal-acrylic, metal-ceramic (PFM), zirconia-feldspathic ceramic, and monolithic zirconia. The relative complications, difficulties, advantages, and recommendations are enumerated in Table 2.

There are only limited long-term data concerning the treatment of the edentulous maxilla using implant-supported fixed prostheses. Jemt and Johansson[28] published a 15-year report of 76 patients treated with 450 machined implants. The 15-year implant and fixed prosthesis cumulative survival rates were 90.9% and 90.6%, respectively. Resin veneer fractures and severe wear were the main complications recorded. Interestingly, loosening of abutment/bridge locking screws was noted. These results should be compared to the 1991 1-year report of implants placed in 391 edentulous maxillae and mandibles, for which Jemt[29] recorded 98.1% and 99.5% success for the implants and prostheses, respectively. In a study recording the outcomes of 46 edentulous patients treated with maxillary prostheses 12 to 15 years after treatment, one framework fracture with acrylic veneer fracture was reported with a second having severe tooth wear, seven ceramic prostheses demonstrated chipping, and one abutment screw fractured.[30]

A recent systematic review of studies (including both maxillary and mandibular implant-supported fixed prostheses) with 5 to 10 or $>$ 10 years follow-up, reported the most commonly observed prosthetic complications were fracture or loosening of abutment and prosthesis screws and fracture of acrylic resin or acrylic resin teeth.[31] These complications appear to continue with time, and the data reinforce the observations made in an early systematic review.[2] Longer-term data will continue to inform the profession of its responsibilities regarding careful planning, providing opportunities for repair and revision, and maintaining implant health for longer than the commonly reported 1- to 5-year outcomes.

A comprehensive assessment of prosthodontic complication rates of maxillary implant-supported fixed prostheses demonstrated the time-dependent nature of the phenomenon. In a meta-analysis of 19 selected reports, there was limited comparison among types of restorations; however, the review demonstrated that within 10 years, a large number of veneer fractures and wear problems were encountered. By 15 years, over 50% of studied prostheses demonstrated fracture or wear of the veneering material.[32] Papaspyridakos et al[2] reported less than 10% prosthetic success (a prosthesis without complication) for implant-supported fixed prostheses at 10 years. The possible improvement of outcomes using ceramic maxillary implant-supported fixed prostheses has received some attention; however, fracture and chipping of crowns and fracture of gingival ceramic remained, particularly in a "development group" of prostheses.[33] Thus, long-term maxillary implant-supported fixed prosthesis success requires maintenance, repair, and possible replacements within the patient's lifetime. This should not be viewed as a limitation of this approach but instead with a rational understanding that the prosthesis has a lifespan and that the patient can be best served by prosthesis designs that are age-appropriate in regard to hygiene, esthetics, phonetics, function, and patient-based expectations, and with the knowledge that these expectations and their priority will change over the lifespan of the patient.

Table 1 Comparison of Implant Retention Mechanisms

Retention mechanism	Potential complications	Difficulties	Advantages	Recommendations
Screw-retained	Screw loosening, screw fracture	Requires ideal implant placement (prosthetically driven) or complex prosthesis	Easy retrieval, extraoral repairs, easier follow-up visits and maintenance	Complex procedure requires experienced team with comprehensive understanding of surgical/restorative aspects Highly experienced dental laboratory with access to CAD/CAM
Cement-retained	Debonding, cement retention, risk of peri-implantitis	Positioning of the crown margin, remaining cement, higher cost when individualized abutments are used, intraoral repairs/limited retrieval options	Better occlusal anatomy	

Table 2 Prosthetic Material Selection

Prosthetic material	Potential complications	Difficulties	Advantages	Recommendations
Metal-acrylic	Frequent fracture of the acrylic teeth, fracture of the pink acrylic material, fracture of the prosthesis when metal reinforcement is not used, discoloration, unstable occlusal contacts (wear)	Long-term survival without complications (fractures, discoloration)	Easy to repair, lower cost	Better for provisional phase Use higher-quality acrylic teeth
Porcelain fused to zirconia	Chipping of the prosthesis veneering material	Esthetics when implants are not correctly placed Difficult to repair	Long-term stability	Control design of the framework and space required for the veneering material Control the occlusion Segmentation of the prosthesis with ideal number of supporting implants
Monolithic zirconia	Unknown long-term results (aging of the material?)	Advanced technology is needed, experienced laboratory is needed, intraoral occlusal adjustments may diminish long-term stability of the material	Reduced possibility for chipping, as there is no need for veneering material	Include prototype prosthesis Lab finishing that avoids adjustments No intraoral occlusal adjustments Segmentation of the prosthesis with ideal number of implants

CONCLUSIONS

The aggregate evidence presented among different prospective studies and existing systematic reviews that reported on prosthetic survival and prosthesis complications permits clinical recommendations regarding the challenges presented in prosthetic rehabilitation of the edentulous maxilla using an implant-supported fixed prosthesis. Based on the reported evidence and expert opinions, it can be stated that:

- Four, six, or more than six implants can be undertaken to provide a maxillary fixed implant prosthesis when rough-surfaced implants, which have survival rates above 95% after 5 years, are used.
- The relative risks of using fewer implants in a tilted array versus distributing more implants, which is often dependent on bone grafting procedures, must be considered at individual patient and clinician levels.
- The use of a one-piece prosthesis is required when few implants are included. The pragmatic advantages of using more implants to support a segmented prosthesis should be included in decision-making for individual patients.
- The procedural diagnostics, treatment, and maintenance for these different approaches all require advanced knowledge and careful communication among the therapeutic team.
- Emerging long-term data on implant-supported fixed prosthesis treatment of the edentulous maxilla suggest that with possible long-term implant survival, the prosthetic therapeutic success requires maintenance, repair, and possible multiple replacements within the patient's lifetime.

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