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Restorative Complications in Full-Arch Implant Supported Prostheses

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Abstract:

The main objective in the treatment of edentulous patients with osseointegrated implants is either to avoid removable complete dentures by placement of complete implant-supported fixed prostheses or to improve the retention and stability of removable complete dentures. The efficacy of full-arch implant supported prostheses is evident in literature with prosthodontic survival rates ranging from 98.61% in 5-years to 92.1% at the 10-year mark. A variety of complications will be encountered at different rates at the 5-, 10- and 15-year marks. This literature review discusses the types of prosthodontic complications and the rates at which they occur.

Introduction

The main objective in the treatment of edentulous patients with osseointegrated implants is either to avoid removable complete dentures by placement of complete implant-supported fixed prostheses or to improve the retention and stability of removable complete dentures (Bozini, Petridis et al. 2011). The efficacy of full-arch implant supported prostheses is evident in literature:

1. In a systematic review by (Papaspyridakos, Mokti et al. 2014) 501 patients with 2827 implants were followed-up over a period of at least 5-years. Majority of the implants (88.5% of all placed implants) were placed in the inter-foramina area. The cumulative implant survival rates for rough surface implants ranged from 98.42% in 5-years to 96.86% in 10-years and for smooth surface implants, survival rates ranged from 98.93% in 5-years to 97.88% in 10-years. The prosthodontic survival rates for 1-piece implant-fixed complete dental prosthesis ranged from 98.61% in 5-years to 97.25% in 10-years.
2. In a descriptive analysis by (Lambert, Weber et al. 2009) 1320 patients with 8376 implants were included and review for up-to 15-years. The overall calculated implant survival rates ranged from 94% at 1-year to 87.7% after 15-years. The implant survival rates for rough-surface implants ranged from 97% at 1-year to 98% after 15-years. Machined implants showed survival rates of 92% at 1-year to 87.7% after 15-years. Implants placed in native bone had greater survival rates than those placed in augmented bone. The prosthodontic survival rate ranged from 98.2% at 1 year to 92.1% at the 10-year mark, and it was only influenced by the implant number and distribution.
3. In a systematic review by Rohlin, Nilner et al. (2012) they reported that full-arch implant supported fixed dental prosthesis is widely accepted as a treatment modality for edentulous patients, presenting high

long-term implant survival rates: 95% after 5 years in patients in the maxillary arch and 97% after 10 years in the mandibular arch. The survival rate of implant-supported fixed prostheses is 95% after 5 years in patients with maxillary edentulism and 97% after 10 years in patients with mandibular edentulism.

However, in the above-mentioned studies the authors concluded that complete fixed implant prostheses present with various prosthodontic complications after long-term function.

In this paper the type of restorative complication and possible solutions will be discussed

Areas where prosthetic complications might originate

According to Bongard and Powell (2018) prosthetic complications can be divided into structural, functional and aesthetic problems. However, they divide prosthetic complications into the 5-phases of treatment regarding the edentulous patient. These 5-phases are:

1. The diagnostic phase

Complications arising from this phase are iatrogenic in nature. They will lead to a suboptimal prosthesis from either a mechanical or an aesthetic perspective. They typically arise from the failure to recognize one or all of the following four main patient features: occlusal vertical dimension, transition zone relative to the smile line, lip support and centric relation position.

1.1 Occlusal vertical dimension and restorative space

The most commonly used material for fixed implant-supported prosthesis is acrylic/resin. One drawback is that this is a generally a weak material and derives its strength from bulk. Because of this, between 12–15 mm of restorative space is required per arch, otherwise, the prosthesis will have higher chance of fracturing. As a result, in most scenarios, there is a need to create the necessary restorative space. This can be achieved in two ways: surgical reduction of the alveolar ridge or increase in vertical dimension of occlusion. Therefore, a determination of the patient's occlusal vertical dimension (OVD) is crucial. If there is a loss of OVD, then there is the potential to gain restorative space by increasing the OVD. If there is no loss of OVD, then the only method to create restorative space is to reduce the alveolar ridge. This too may not always be feasible because, on occasion, the necessary alveolar ridge reduction results in inadequate remaining bone for the placement of dental implants (Sadowsky and Hansen 2014) (Sadowsky, Fitzpatrick et al. 2015).

1.2 The transition zone

The transition zone is the prosthesis-gingival junction. In a non-posed smile, if the transition zone is revealed, then additional alveolar ridge reduction must be performed at the time of surgery. This is true even if there is adequate restorative space for the fixed prosthesis. Otherwise, the contrast from synthetic pink acrylic and natural pink gingiva will be evident and this will result in a highly suboptimal aesthetics.

1.3 Lip support

Patients that have had removable prostheses for an extended period often required a buccal flange to provide lip support for aesthetics. Fixed prostheses cannot have a buccal flange because a concave intaglio surface would collect plaque and food debris, thereby preventing access for proper hygiene.

1.4 Centric relation

Most of the patients seeking treatment with full-arch fixed prostheses have a broken-down dentition that forces them to develop a modified jaw position in order to masticate their food. Therefore, capturing the patient's jaw relationship in this habitual position is likely to be inaccurate and results in transitional fixed prostheses that do not occlude with an even force distribution. As a result, the interim prostheses are much more prone to fracture. In order to avoid this scenario, clinicians should capture interocclusal record in centric relation, which is the most predictable position available.

2. Surgical phase

Prosthetic complications that result from this phase are both iatrogenic and irreversible. Firstly, the actual surgical procedure is simplified when the diagnostic phase was carefully carried out. However, it is now the surgeon's responsibility to accurately carry out the prosthodontic plan. This primarily includes adequate reduction of the alveolar ridges to create adequate restorative space for prosthetic material and to mask the transition zone for optimal aesthetics. Secondly, the surgeon's challenge is to simultaneously place the dental implants within the confines of the bone and the anticipated boundaries of the prosthesis. Placement of the implants outside the confines of the prosthesis is a common occurrence. This is particularly true with the inexperienced surgeon and especially without the proper use of a surgical stent. When this occurs, the prosthesis will extend beyond the limits of the neutral zone, the areas in the oral cavity where the forces between the tongue and cheeks or lips are equal. Lastly, one step commonly omitted from the surgeon's checklist is the osseous recontouring of the alveolar ridge to create an optimal tissue bed for the intaglio surface of the prosthesis. While there is limited evidence to suggest which prosthesis, contours are most ideal for hygiene maintenance of an implant-supported full-arch fixed prosthesis, it is evident from other aspects of dentistry that convex contours are the easiest to keep clean.

3. Transitional prosthodontic phase

The transitional phase begins as soon as the implants are loaded with the interim fixed provisional prosthesis and it overlaps with the definitive phase, where the final prosthesis is being fabricated. The interim prosthesis is made entirely of acrylic; hence this prosthesis is inherently weaker and prone to fracture. In fact, fracture of the provisional acrylic prosthesis is also one of the most commonly reported prosthetic complications (Menini, Signori et al. 2012). Fortunately, acrylic is easily reparable and with adequate laboratory support same-day repairs are feasible. In patients with parafunctional habits or a history of multiple prosthetic fractures, precautions should be taken to minimize the risk of future fractures and simplify future repairs. These include the reduction/elimination of all cantilevered portions of the prosthesis (Drago 2017), incorporation of metal wire reinforcement and verification that the occlusion is evenly distributed amongst all the prosthetic teeth. More than anything, the transitional phase is an opportunity to correct prosthetic challenges that have occurred from the first two phases, allow patients to adapt to their prostheses and attempt to prevent future issues. This includes correcting aesthetic issues, providing time for healing and osseointegration, evaluating the patient's propensity to fracture their prostheses and intercepting occlusal issues. Ultimately, this period will allow the practitioner to make decisions regarding desired changes for the definitive prosthesis.

4. Definitive prosthodontic phase

The definitive phase is the stage in which the final prosthesis is designed and fabricated. Modifications in the occlusion and aesthetics have been performed on the provisional prosthesis and the patient has been able to provide subjective feedback. The most critical aspect of the definitive phase to avoid prosthetic complications is that the final prosthesis framework exhibits complete passivity on the implants (Spazzin, Camargo et al. 2017). Otherwise, there will be undue strain on the prosthetic screws retaining the prosthesis. Lack of passive fit has been attributed as the main cause for screw loosening and ultimately screw fracture (Papaspyridakos, Chen et al. 2012). Milled titanium frameworks have been shown to achieve passive fit with greater frequency than conventionally cast frameworks (Drago and Howell 2012). Similarly, to the interim prosthesis, there should be careful consideration for the cantilever extension. Greater cantilever arms are more likely to lead to framework deformation, prosthetic tooth delamination and ultimately framework fracture. This will occur where the metal framework meets the most distal implant (Drago 2017). While the cantilever can extend further than with the provisional prosthesis, it should not extend beyond 1.5 times the A-P spread (Drago and Howell 2012). Finally, there should not be any prominent occlusal contacts on the cantilevered portion.

5. Maintenance phase

Finally, the maintenance phase begins as soon as the definitive prosthesis is inserted and extends indefinitely. At this point, prosthetic complications are simply an eventuality. Unlike some of the other phases of treatment, they are not iatrogenic in nature. They will take place because of the limitations of the material.

Frequency and type of prosthetic complications

According to Papaspyridakos et al. (2012) structural complications accounted for most of the prosthodontic complications. By far, the most commonly reported prosthesis-related structural complication was fracture of veneering acrylic, which had an estimated complication rate of 33% at 5-years and 66% at 10-years. Secondly, the most commonly reported implant-related structural complication was prosthetic screw loosening with an estimated 5- and 10-year complication rate of 10% and 20%, respectively. Other structural complications, in decreasing order of incidence, were loss of access channel restoration, prosthesis wear and need for total replacement of acrylic resin teeth, prosthetic screw fracture, fracture of opposing restoration and fracture of the metal framework. Papaspyridakos et al.

(2012) reported that biologic and technical complications routinely occur with metal-acrylic full-arch implant supported prostheses. The 10-year estimated rate for prostheses free of complications was reported to be 8.6%.

In a meta-analysis of prosthodontic complications of implant-supported fixed dental prostheses in edentulous patients (Bozini, Petridis et al. 2011) the type and rate of complications associated with metal-acrylic restorations were discussed. These restorations consisted of denture teeth connected to a metal framework with acrylic resin and were attached with screws to six implants placed between the mental foramina. A very similar prosthetic design is being used today on four to six implants in the mandible. The findings are presented in table form:

Complication	5-year rate	10-year rate	15-year rate
1. Veneer fracture	30.6%	51.9%	66.6%
2. Material wear	17.3%	31.6%	43.5%
3. Prosthetic screw loosening	5.3%	10.3%	15%
4. Abutment screw loosening	4.7%	9.2%	13.4%
5. Prosthetic screw fracture	4.1%	8%	11.7%
6. Aesthetic deficiencies	3.1%	6.1%	9%
7. Framework fracture	3%	6%	8.8%
8. Abutment screw fracture	2.1%	4.3%	6.3%

All the above mention complications are associated with metal-acrylic restorations. Full-arch zirconia restorations were introduced to overcome the above-mentioned complications.

In a prospective clinical trial by Caramês et al. (2019), 150 patients were rehabilitated with 83 and 110 implant-supported, screw-retained, full-arch ceramic-veneered zirconia rehabilitations (group 1) and monolithic zirconia with porcelain veneering limited to buccal rehabilitations (group 2), respectively. The follow-up period for both groups were just over 2 years. Implant success rate for both groups were very high, 99.53% for group 1 and 99.83% for group 2. Out of the total 177 restorations, only one framework fracture was observed in each group during the follow-up period, resulting in prosthetic survival rates of 98.7% (group 1) and 99.0% (group 2). Chipping of porcelain (minor and major) was recorded at 7% for group 1 and 5% for group 2 over the observation period. The authors did notice that when both the maxilla and the mandible were restored with zirconia prostheses the chipping rate increased. They concluded that this finding could be explained that in bi-maxillary full-arch implant-supported rehabilitations a decrease in the patient proprioceptive defense mechanism is noted due to the functional ankylosis of the dental implants in both arches, leading to higher forces, which in turn could exacerbate the rates of mechanical complications.

In a retrospective study by Bidra et al. (2018) 2039 zirconia prostheses were evaluated, 319 prostheses had a minimum of 3-years of clinical service, and 69 prostheses had a minimum of 4-years. A total of 6 fractures were reported, resulting in a first-year survival rate of 99.8% and a 5-year cumulative survival rate of 99.3%. 6 zirconia prostheses were returned to the laboratory during the 5-year period because of technical complications related to the debonding of titanium cylinders, and 3 prostheses were returned because of fracture of the titanium cylinders. No prostheses were returned because of chipping of the veneered gingival porcelain. All 6 frameworks fracture in bi-maxillary full-arch implant reconstruction cases and reasons for the failures were:

1) not enough restorative space (1)
2) inaccurate impression (4)
3) inadequate framework design – not enough material (1)

The authors recommended the following to increase survival rates and better outcomes with monolithic zirconia full-arch implant supported restorations:

1) the use of superior quality of zirconia.
2) careful adherence to laboratory protocols, including the slow heating and cooling of the zirconia.
3) mandating a minimum of 12-mm prosthetic space above the soft tissue level to provide sufficient strength for the zirconia and to comply with the terms of the warranty.
4) use of the implant manufacturer's titanium cylinders bonded to zirconia to provide a metal-to-metal interface over the implants or abutments.
5) provision of a milled acrylic resin prototype prosthesis in most situations (in some situations, the clinicians opted against this recommendation) to allow adjustment of occlusion and esthetics before fabricating the zirconia prosthesis.
6) quality control at every step of fabrication, including returning questionable impressions, casts to the clinician for reverification.

Regarding metal-ceramic full-arch implant supported prostheses the long-term outcomes regarding survival rates and complications are scarce according to Papaspyridakos et al. (2019). The use of metal-ceramic prostheses became popular in implant dentistry in the mid-1990s and early 2000s because metal-ceramic prostheses were considered the gold standard in fixed prosthodontics. In a retrospective study by Papaspyridakos et al. (2019) the biological and technical complications of metal-ceramic full-arch implant supported rehabilitations were recorded over a period of 1 to 12-years (median of 5-years). 40 patients with 55 metal-ceramic full-arch implant supported restorations were reviewed. They reported the following:

1) Of 359 moderately rough surface dental implants, 2 had failed in 1 patient after 11 years of functional loading, yielding a cumulative implant survival rate of 99.4%.
2) 1 of 55 edentulous arches restored with a metal-ceramic full-arch implant supported prosthesis failed, yielding a cumulative prosthesis survival rate of 98.2% after mean observation period of 5-years.
3) Soft tissue recession was the most frequent minor biologic complication (annual rate 7.8% at the prosthesis level) for both cement and screw-retained groups.
4) Peri-implantitis (annual rate 1.6% at the implant level) the most frequent major biologic complication.
5) Wear of porcelain (annual rate 8.0% at the prosthesis level) was the most frequent minor technical complication for both groups.
6) Fracture of porcelain (annual rate 0.8% at the dental-unit level) was the most frequent major technical complication.
7) Minor complications were the most frequent in both the groups (cement and screw retained).

A summary of the complications:

Complication	5-year rate	10-year rate
1. Prostheses free of biologic complications	50.4%	10.1%
2. Prostheses free of technical complications	56.4%	9.8%
3. Minor technical complications (chipping)	13%	26%
4. Minor technical complications (wear)	8%	
5. Major technical complications (fracture)	4%	8%
6. Minor biological complications (Soft tissue recession and/or dehiscence, inflammation under fixed prosthesis, peri-implant mucositis, hypertrophy/ hyperplasia of soft).	50%	100%
7. Major biological complications	8%	16%

In another systematic review and meta-analysis by Wong et al. (2019) they reported on the 5 and 10-year cumulative complication rates for metal-ceramic full-arch implant-supported fixed prostheses, where veneer fractures were 22.1% and 39.3%, respectively. They also reported on all-ceramic full-arch implant-supported fixed prostheses with a 100% survival rate, but differed in success rates, with monolithic zirconia restorations at 90.9%, and bi-layered zirconia at 60.4%, with complications attributed to veneer fracture. Their conclusion was that metal-ceramic and all-ceramic full-arch implant-supported fixed prostheses presented with veneer fractures as primary complication and that this may require significant maintenance. Other complications were:

5-year Complication rate	Metal-acrylic	Metal-ceramic	All-ceramic
1. Prosthetic screw loosening	5.3%	0.72%	1.43%
2. Abutment screw loosening	4.7-9.3%	0.91%	0
3. Prosthetic/abutment screw fracture	2.1-10.4%	0	0
4. Framework fracture	3-4.9%	0.43%	0

The authors did comment that longer studies are required to evaluate all-ceramic full-arch implant supported fixed prostheses.

Papaspyridakos et al. (2019) reported on outcomes and complications after a mean follow-up of 5-years of double full-arch fixed implant-supported prostheses. 19 edentulous patients restored with 38 full-arch implant-supported fixed prostheses were follow-up for 5.1-years. A total of 249 implants were placed and 2 implants failed after a mean observation period of 5.1 years, with an overall implant survival rate of 99.2% and prosthesis survival rate of 92.1%. 3 out of 38 full-arch implant-supported fixed prostheses were lost, 1 after implant losses and 2 due to technical complications. The most frequent minor biologic complication was soft tissue recession with an estimated 5-year rate of 45.5%, while the most frequent major biological complication was peri-implantitis with an estimated 5-year implant-based rate of 9.5%. The most frequent minor technical complication was wear of the prosthetic material with an estimated 5-year rate of 49.0%, while the most frequent major technical complication was fracture of the prosthetic material with an estimated 5-year dental unit-based rate of 8.0%. Overall the 5-year estimated cumulative rates for "prosthesis free of biologic complications" was 50.7% and for "prosthesis free of technical complications" was 57.1%.

Technical complications are common in all forms of prosthetic dentistry and often jeopardize the function and/or esthetics of a given prosthesis. Full-arch implant fixed dental prostheses are not exempted from these complications and metal-acrylic implant fixed prostheses present with a varying frequency of different complications, with veneer fracture being the most frequent. Acrylic resin veneers require sufficient material thickness and support from the underlying frameworks to withstand forces in the oral cavity. Veneer fractures may be caused by material failure, design issues, and/or technical errors. Many of these factors can be controlled with technical excellence, but the high incidence of acrylic resin failures in prosthodontics suggests that the problem cannot be eliminated completely. The inherent weakness of acrylic resin denture teeth is also evident in the frequency of wear. Different options are available to slow the process of tooth wear, including altering the denture tooth surface with amalgam or gold alloy or using porcelain denture teeth. The frequency of both acrylic resin fractures and wear is influenced by such factors as the opposing dentition and the presence of parafunctional habits. When acrylic resin veneer fractures or wear occur, the ability to remove and repair the prosthesis, as is the case with screw-retained metal–acrylic implant fixed dental prostheses, is a distinct advantage. However, the high frequency of these particular complications indicates the need to inform prospective implant patients of future maintenance requirements. Bagegni et al. (2019) reported on the prosthetic survival rates over a period of 3-years of full-arch implant supported prostheses fabricated from different materials (5-types of restorative materials were identified (porcelain-fused-to-non-precious alloy, porcelain-fused-to-zirconia, precious-metal-acrylic, non-precious-metal-acrylic and PMMA) and found the following:

Prosthesis	3-year survival rate	3-year chipping rate
1. Metal-ceramic	95%	8%
2. Metal-acrylic	97%	22%
3. All-ceramic	97%	15%

Screw-related complications are commonly reported in the dental literature. Regardless of their design, implant screw joints are susceptible to screw loosening or fracture because of the magnitude and direction of oral forces and the strength limitations of the components. Various factors may contribute to screw complications: inadequate preload on the screws, overtightening of the screws leading to stripping and/or screw deformation, and/or occlusal overload from parafunction, occlusal interferences, or excessively long cantilevers.

Abutment screw loosening and abutment screw fracture events are low. The same can be said for prosthetic screw loosening and fracture. Some of the authors mentioned that hand-tightening was used instead of a calibrated torque instrument (L'Homme-Langlois, Yilmaz et al. 2015).

Fracture of the metal framework is a non-reversible complication that usually leads to a remake of the prosthesis. Framework fractures were present to only a minor extent in the majority of the studies in the present systematic review (Bozini, Petridis et al. 2011). The most common reasons cited responsible for framework fractures were poor alloy choice and decreased cross-sectional dimension distal to the most posterior implant. Most fractures occurred at the beginning of the cantilever arms. Thus, it can be concluded that the cantilever arms should be kept as short as possible and the bulk of the framework increased around the last abutment. Special attention should be given to the selection of the alloy type, the framework design, and the height of the framework.

Conclusion

Maintenance for full-arch implant-supported fixed prostheses can be time consuming and costly. The prospective implant patient should be informed not only about the expected outcome of the treatment but also about its limitations. For the informed consent to treatment to be valid, the patient must be made aware of the risks of the treatment, the complications that may arise, and the additional costs involved in correcting them. The literature suggests that, in the hands of experienced operators, complications occur frequently enough to concern clinicians of lesser experience. The material choice and retrievability of full-arch implant supported fixed prostheses are therefore an important consideration in delivering high-quality, patient-based treatment outcomes.

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