Predictors of implant loss with rehabilitation of edentulous jaws with implant-assisted complete prostheses

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A critical appraisal of a systematic review: Kern J-S, Kern T, Wolfart S, Heussen N. A Systematic review and meta-analysis of removable and fixed implant-supported prostheses in edentulous jaws: post-loading implant loss. Clinical Oral Implants Research 2015 doi: 10.1111/clr.12531
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Summary

Systematic review conclusion: Implant location, type of restoration, and implant number do have an influence on the estimated implant loss rate. In general, conventional loading tended to result in fewer implant losses. However, the implant loss rate for fixed prostheses in maxilla and mandible did not significantly differ concerning immediate and conventional loading. It has to be noted, though, that immediate loading was generally attached to strict conditions (e.g., a pre-defined insertion torque). Consistent reporting of high quality clinical studies are needed to confirm the present results.

Critical appraisal conclusion: Although implant location (maxilla), immediate loading, lesser implants number may be predictors of implant losses with fixed or removable prostheses in rehabilitation of edentulous jaws, the clinical relevance thereof may be unimportant or insignificant.

Implications for clinical practice: Decisions regarding treatment choices and outcome of treatment for the rehabilitation of edentulous jaws cannot be based on implant loss or survival alone, but rather a fusion of quality evidence-based knowledge, patients' preferences and values and clinical expertise of care providers. Implant-assisted fixed prostheses (IAFP) cannot be seen as superior or a better choice than implant-assisted removable prostheses (IARP). There are specific indications where either may be a better choice depending on anatomical, biological, physical, aesthetic, biomechanical and financial constraints and limitations.

Clinical question

Is there an impact of implant location (maxilla vs. mandible), implant number, type of prosthesis (fixed vs. removable) and/or different anchorage systems on the implant loss rate concerning the implant-prosthodontic rehabilitation of edentulous patients?

Review methods

Methodology

This study followed the *Preferred Reporting Items for Systematic Reviews and Meta-analysis* (PRISMA) guidelines.[1] Potential risk of bias within the included studies was assessed using the methodology checklists provided by the Scottish Intercollegiate Guidelines Network (SIGN).

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Search strategy and study selection

The investigators did an electronic search of the PubMed (Medline), Cochrane Library, and Embase database up until May 7, 2014 for eligible studies. The authors also conducted a supplementary manual search in different German dental journals, including reference lists of available publications, and private databases (End Note libraries). No restrictions were placed on the year or language of publication. The study selection and data extraction were performed independently by two reviewers. Inter-reviewer disagreement was resolved by discussion. Consistency between reviewers was assessed using Cohen's Kappa statistic. Authors of available studies were contacted per mail in case of unclear data.

Eligibility and exclusion criteria

Studies had to meet the following eligibility criteria to be included in the review: (i) edentulous patients (both jaws or either upper or lower jaw) with an implant-retained fixed or removable prosthesis; (ii) measurement of implant survival rate or number of implant losses following prosthetic loading after an observation period of at least 3 years; and (iii) randomized-controlled trials (RCTs) or prospective clinical studies.

Outcome measures and data extraction and synthesis

The primary outcome measured was the estimated implant loss rate in the edentulous maxilla and mandible. Implant loss rate was defined as the risk of an implant loss considering 100 implants placed over the course of 1 year or the risk of an implant loss considering 10 implants placed over 10 years.

The following predetermined variables were recorded for subgroup analysis of the primary outcome according to: type of prosthesis (fixed or removable), type of anchorage system (bar/ball/telescopic crowns, screw-retained/cemented), number of implants, implant surface, and loading protocol (immediate or conventional).

A multivariate Poisson regression model was used to statistically analyze the independent effects and interrelation between factors influencing the estimated implant loss rate. Assessment of possible publication bias or selective reporting was not performed. The complexity of multiple variables and inconsistent reporting of results among studies did not allow for a classical analysis in form of a forest plot to compare different intervention groups.

Main results

Study characteristics

A total of 54 studies were included in the qualitative analysis of the systematic review. The inter-reviewer agreement was almost perfect [κ = 0.9 (SD 0.098)].

Ten (10) studies investigated the edentulous maxilla, 36 the edentulous mandible, and 8 investigated both edentulous jaws. Four (4) studies were RCTs, the others (50) prospective clinical studies. Follow-up observation periods ranged between 3 and 10 years. Within the 54 included clinical trials, a total of 81 study populations were investigated. In 30 study populations, patients were restored with implant-supported fixed full-arch prostheses, and in the residual 51 study populations, patients received implant-supported removable overdentures. All of the fixed, definitive prostheses had a metal framework (Au, CoCr, or Ti), veneered with acrylic resin or ceramic and were screw-retained. The removable prostheses were generally fabricated out of acrylic resin, reinforced with a metal framework and attached by different anchorage systems (ball, locator, telescopic crown as un-splinted retention elements and different bars enabling a primary splinting).

A total of 2368 patients received 9267 implants. Various titanium implant types with different surface modifications, lengths and diameters were used. Implant numbers per patient varied between 1 and 6 implants in the mandible and 2 and 10 in the maxilla. The inter-foraminal area was the preferred area for implant positioning in the mandible. If only one implant was inserted in the edentulous lower jaw, it was located in the midline symphysis, representing the absolute minimal treatment concept. In the maxilla, implant positions were often not described precisely.

Implant location

The estimated 5-year survival rates of implants were 97.9% [95% CI 97.4; 98.4] in the maxilla and 98.9% [95% CI 98.7; 99.1] in the mandible. Corresponding implant loss rates per 100 implant years were significantly higher in the maxilla [0.42 (95% CI 0.33; 0.53)] compared to the mandible [0.22 (95% CI 0.17; 0.27)] (P = 0.0001).

Type of prostheses

Implant loss rates for fixed prostheses [0.23 (95% CI 0.18; 0.29)] were significantly lower compared to removable prostheses [0.35 (95% CI 0.28; 0.44)] (P = 0.0148). No significant differences in the estimated implant loss rates could be detected in the mandible between fixed [0.19; (95% CI 0.13 - 0.27)] compared to removable prostheses [0.24; (95% CI 0.18- 0.32)] (P = 0.2980).

Number of implants

Implant loss rates for maxillary implant-supported

overdentures on <4 implants [7.22 (95% CI 5.41; 9.64)] were significantly higher than on four implants [2.31 (95% CI 1.56; 3.42)] (P < 0.0001). In the mandible, an implant-supported fixed prosthesis on four implants resulted in significantly higher implant loss rates compared to a fixed prosthesis on five or more implants. A mandibular overdenture on one implant also had a greater risk of implant loss compared to a mandibular overdenture on two implants. The same (lower implant number = higher implant loss rate) applied when comparing 2 vs. 4 implants with a mandibular overdenture. Comparing different implant numbers, less implants always resulted in significantly higher implant loss estimations (1 vs. 2, 2 vs. 4 (removable prostheses) 4 vs. ≥5 implants (fixed prostheses). Four implants with a fixed implant-supported prosthesis resulted in a significantly higher (P < 0.0001) estimated implant loss rate (0.79 [95% CI 0.49; 1.30]) than with a removable implant-supported prosthesis (0.11 [95% CI 0.06; 0.23]).

Type of attachment system

Regarding different attachment types for overdentures in both jaws, no significant differences in the estimated implant loss rate could be detected between ball [0.34 (95% CI 0.16; 0.72)] and bar attachment [0.20 (95% CI 0.14; 0.28)]; P = 0.1499). The comparison of bar vs. telescopic crown and ball vs. telescopic crown was not possible due to inadequate data.

Implant surface

Although machined implant surfaces seems to result in higher implant loss rates [0.28 (95% CI 0.21; 0.37)] compared to rough surface implants [0.19 (95% CI 0.13; 0.28)] no significant difference in post-loading implant loss could be demonstrated (P = 0.1177). There was also no statistically significant difference in estimated implant loss per 100 implant years between machined [0.25 (95% CI 0.17; 0.36)] and rough implants [0.21 (95% CI 0.16; 0.27)] (P = 0.4518) in the edentulous mandible.

Loading protocols

In the overall analysis the estimated implant loss rate was greater for immediate [0.40 (95% CI: 0.27; 0.60)] compared to conventional loading [0.24 (95% CI: 0.19; 0.28)] (P=0.0151) (individuals with less than 4 implants were excluded from this analysis). A significantly lower risk of implant loss was observed when a conventional loading protocol was associated with a removable implant-supported prostheses in the edentulous mandible.

Conclusion

The study suggests that fixed implant-supported prostheses show slightly but significantly better results than implant-supported removable prostheses in either jaw. In general, conventional loading tended to result in fewer implant losses. However, the implant loss rate for fixed prostheses in maxilla and mandible did not significantly differ concerning immediate and conventional loading. It has to be noted, though, that immediate loading was generally attached to strict conditions (e.g., a pre-defined insertion torque). Implant location, type of restoration, and implant number do have an influence on the estimated implant loss rate. Consistent reporting of clinical studies is necessary and high-quality studies are needed to confirm the present results.

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Commentary

Background and importance

Edentulism remains a major health problem world-wide and treating edentulous patients presents many challenges for clinicians. Although complete dentures still remain the conventional therapy for full edentulism, this kind of rehabilitation might not be considered by edentate patients and dentists as the best choice of treatment any longer due to its diversity of functional, biological, aesthetic and social problems. Most of these problems can now successfully be reduced through the introduction of osseointegrated dental implants. The traditional therapeutic paradigm for the treatment of edentulism has shifted from conventional dentures to implant-assisted complete prostheses (a new terminology encompassing all types of complete prostheses retained or supported by implants).[2] The implant-assisted fixed prostheses (IAFP) (fixed dentures) are totally supported by implants and can only be removed by the clinician, whereas implant-assisted removable prostheses (IARP) (implant-overdenture) are usually supported by implants and soft tissues, but can also be supported by implants alone, depending on the superstructure used[2] and can be removed by the patient themselves.

Various challenges exist regarding the most appropriate, and predictable implant-assisted restoration for the edentulous

patient. These challenges are mainly due to individual anatomic, biomechanical, aesthetic and cost considerations.[3] Decisions regarding the optimal number of implants, anchorage system, suprastructure design, expected maintenance, and immediate loading protocols remain controversial.[3] The authors have in this review analized and compared the potential influence of some of these controversial factors on the outcome of dental implants in both IAFP and IARP for maxilla and mandible in edentulous patients.

Are the results valid?

This review presented with serious limitations that could potentially affect and distort the estimates of effect. First and foremost, the authors presented a rather confusing and over ambitious 'focused question' that complicated the analysis and synthesis of the data. The population, intervention, comparison and outcome (PICO) were poorly defined and multiple and heterogenous criteria were stated for each of the parameters making the review very complex.

Inclusion or exclusion criteria were not consistent amongst the individual studies. The few RCT's included in this review did not directly address the focused question. Important biological and technical complications as well as patient-related outcomes were not included in the focused question and therefore not analysed. The review lacked high-quality comparative clinical trials (i.e RCT's). Most studies included in this review were of an observational nature and therefore considered as a low level of evidence. The estimated implant loss rates and survival estimations were mostly derived from non-comparative studies. Individual studies presented with a high level of heterogeneity and inconsistent reporting of data (if reported at all) complicating a meaningful analysis of the data. The calculation of the "implant loss rate per 100 implant years" is based on the assumption of a constant event rate over time. Very short or long observation periods, as observed in this study, may result in distortion of estimate of effects. Furthermore, studies investigating implants in either local or augmented bone (four studies) that were pooled could also potentially have an effect on the estimated outcome measured.

Individual studies disregarded many confounding variables such as, anatomic position of implants, bone quality, jaw relationship, peri-implant soft tissue condition, condition or type of restoration of the opposing jaw, implant related components, as well as systemic conditions that could potentially have an affect post-loading implant loss. Most of the included clinical cohort studies or RCTs were of an acceptable or high quality, meaning "some flaws in the study with an associated risk of bias" or little to no risk of bias. Selective reporting or publication bias could not be ruled out, especially as some of the studies were sponsored by dental companies or associated with a foundation.

Overall, the lack of good quality comparative trials, heterogeneity and inconsistency in research methodology amongst individual studies, risk of bias, lack of controlling confounding factors resulted in poor quality of evidence therefore potentially reducing the validity of the results.

What were the key findings?

Disregarding the potential confounding factors and considering only the estimated post-loading implant loss the following statements can be made regarding key findings in this review.

Type of prosthesis

Overall, IAFP showed slightly but significantly less implant losses than IARP in either jaw. The risk for implant loss in the edentulous mandible was significantly lower than in the maxilla. It should be noted that rehabilitation of the maxillary edentulous patient with implant-assisted prosthesis is often more challenging than the mandibular arch due to anatomic, biomechanical, and esthetic considerations.[3] A systematic review of RCT's and 5-year follow-up studies revealed that the type of removable and fixed prosthesis had no effect on implant survival and successes.[4] In contrast, another systematic review of longitudinal studies with a least 5 years follow-up[5] found that implant loss was higher for overdentures than for those with IAFP with failures located primarily in the maxilla.

Location and number of implants

In the maxilla, the insertion of six or more implants for an IAFP, and four or more implants for an IARP, showed favorable results. Data on minimal restorative concepts with less than 4 implants in the maxilla is scarce and demonstrated significantly worse results, calling for a cautious and controlled application of these restorative options.

In the lower jaw, the "gold-standard concept" of two implants with an overdenture seemed to be strengthened by the results of this review. The insertion of four implants for a fixed restoration in the edentulous mandible showed satisfying results with a further reduction in implant losses with 5 or more implants. Data on the minimal restorative concept with an overdenture supported by only one implant is scarce and shows promising results provided rough surface implant with conventional loading is used. The application of this therapeutic option can only be recommended, when the insertion of 2 or

more implants is not feasible, e.g. due to economic reasons. Nevertheless, to date there are no comparative trials, let alone RCT's, available to assess the optimal number and position of implants for maxillary IAFP and IARP. [3]

Loading protocol

In general, conventional loading resulted in fewer implant losses compared to the immediate loading protocol. However, the implant loss rate for fixed prostheses in maxilla and mandible did not significantly differ concerning immediate and conventional loading. This corroborates the findings of another recent meta-analysis, that with assiduous patient selection, use of roughened implant surfaces, immediate loading (given a 30Ncm insertion torque) with an IAFP, has the same effect on implant survival as with early or conventional loading.[6]

A conventional loading protocol with removable overdentures still seems to result in a superior outcomes in terms of post-loading implant loss. Other systematic reviews also support the view that IARP with conventional loading protocols result in fewer failures compared to immediate loading. [7]

Implant surface

Rough-surfaced implants demonstrated more favorable results compared to machined implants. The superior results for rough implant surfaces in almost all of the subgroups were not surprising due to better osseointegration capabilities of rough-surfaced implants that have been shown in previous studies.[8, 9] There is a general consensus that roughening the implant surface leads to a stronger bone response.

Type of attachment system

Although IARP in the completely edentulous jaw, showed excellent outcomes in terms of post-loading implant losses, no statistically significant differences for post-loading implant loss could be assessed between bar or ball anchorage systems. Prosthesis related technical complication were not taken into consideration in this review.

How are the results of this review applicable in clinical practice?

It is obvious that the "best" choice of an implant-assisted prosthesis cannot simply be based on results presented in this review.

Various other factors also play an important role in the outcome of treatment when rehabilitating the edentulous jaw. In this context, it is important that clinicians consider anatomic (jaw relationships, inter-arch space), biological (bone quality and quantity, soft tissue conditions,), aesthetic (lip support), and bio-mechanical (opposing dentition, para-functional activity) factors. Treatment planning should also take into account patient preferences and values and factors influencing their quality of life, ability to maintain oral hygiene, treatment time, as well ability to afford care. These considerations take first priority when making choices in the clinical decision-making process.

An IARP is recommended in those patients that have an opposing dentate arch and where there is a potential for parafunctional activity because the overdenture can be removed at night. An IARP is also preferred in cases with moderate to severe atrophy, a concave and prognathic profile, inadequate lip support and phonetic problems. An IARP would in such cases allow for the construction of labial flanges to provide aesthetic lip support and better seal to improve phonetics. If hard and soft tissues have to be replaced horizontally (e.g. for lip support), the IARP is still the better choice. A further physical constraint is that an IARP requires more inter-arch vertical space to provide room necessary for superstructures and attachment system.

Hygiene is more difficult with an IAFP and should be discussed with the patient. Elderly patients who may lack dexterity, and for patients with poor oral hygiene, the IARP may be the preferred choice of prosthesis because it can be removed and therefore easier to clean. IAFP are generally recommended for younger edentate patients, those suffering from prosthesis-related recurrent sores, and those with an excessive gag reflex. Patients with anatomic constraints such as high muscle attachments, tori, knife-edge ridges may be more satisfied with IAFP. However, for an IAFP a minimum of four implants is needed and therefore cost could be a limiting factor. Abovementioned factors were not analyzed in the review and also hold great importance on the choice and success of treatment.

Increasing the number of implants per prostheses decreases cost efficiency of treatment and therefore has to be weighed up and balanced against the risk of using a less implants. This is why the mandibular two-implant overdenture has been recommended as the minimal standard of care for edentulous patients.[10] In comparison the edentulous maxilla is usually successfully restored with conventional dentures.[2] However, implant-assisted prostheses could be considered for those patients with advanced maxillary bone resorption or patients who desire a fixed prosthesis. Patients complaining of inadequate stability or retention could potentially benefit from this treatment modality. Elderly patients who may lack dexterity, and for patients with poor oral hygiene, the IARP may be the preferred choice of prosthesis because it can be removed and therefore easier to clean.

Initial time, treatment costs and maintenance needs are significantly higher for IAFP whereas mandibular IARP seem to be the best option in terms of cost-effectiveness.[11, 12]

The dentist's experience combined with the patient's values and wishes remains an important component of the treatment decision-making process and evidence-based dental care. For those who wish to learn more about the indications of prosthetic design, treatment planning and clinical decision-making regarding implant-assisted complete prostheses, I strongly recommend that they read the excellent critical reviews by Sadowsky and- co-workers,[2] and Emami and co-workers.[3]

Clinical Resolution

The risk for implant loss in the edentulous mandible is significantly lower than in the maxilla. In the maxilla, the insertion of six or more implants for an IAFP, and four or more implants for an IARP have a lesser risk of implant loss compared to when less implants are place. In the lower jaw, the "gold-standard concept" of two implants with an IARP seemed to be strengthened by the analyses of this systematic review. The insertion of four implants for an IAFP in the edentulous mandible showed satisfying results. Conventional loading resulted in fewer implant losses compared to the immediate loading protocol. Rough-surfaced implants demonstrated less implant losses compared to machined implants.

Interpretation of the results should however be done with caution due to lack of comparative trials and considerable heterogeneity between individual studies. It should also be noted that a 'statistical significant' result, does not necessarily imply that there is a clinically significant result. Thus the results should be viewed in context and within the boundaries set by this review.

Decisions regarding treatment choices and outcome of treatment for the rehabilitation of edentulous jaws cannot be based on implant loss or survival alone, but rather a fusion of quality evidence-based knowledge, patients' preferences and values and clinical expertise of care providers. Important considerations in achieving a successful treatment outcome should include bone and jaw related factors, prosthetic limitations, aesthetic issues, financial constraints, hygiene capacity and patient-related quality of life outcomes in the treatment planning process.

Disclosure and Disclaimer

Dr Johan Hartshorne is trained in clinical epidemiology, biostatistics, research methodology and critical appraisal of research evidence. This critical appraisal is not intended to, and do not, express, imply or summarize standards of care, but rather provide a concise reference point for dentists to aid in understanding and applying research evidence from referenced early view or pre-published articles in top ranking scientific publications and to facilitate clinically sound decisions as guided by their clinical judgement and by patient needs.

References

1. Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. Ann Int Med 2009; 151: 264-269.

2. Emami E, Michaus P_L, Sallaleh I, Feine JS. Implant-assisted complete prostheses. Periodontology 2000, 2014; 66: 119-131.

3. Sadowsky SJ, Fitzpatrick B, Curtis DA. Evidence-based criteria for differential treatment planning of implant restorations for the maxillary edentulous patient. J Prosthodont 00 (2014); 1–14, doi: 10.1111/jopr.12226

4. Bryant SR, MacDonald-Jankowski D, Kim K. Does the type of implant prosthesis affect outcomes for the completely edentulous arch? Int J Oral maxillofac Implants 2007; 22 (Suppl): 117-139.

5. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol 2002; 29 (Suppl 3): 197-212.

6. Papaspyridakos P, Chen C-J, Chuang S-K, et al. Implant loading protocols for edentulous patients with fixed prostheses: A systematic review and meta-analysis. Int J Oral Maxillofac Implants 2014; 29(Suppl): 256-270.

7. Schimmel M, Srinivasan M, HerrmannFR et al. Loading protocols for implant-supported overdentures in the edentulous jaw: A sytematuc review and meta-analysis. Int J Oral Maxillofax Implants 2014; 29 (Suppl): 271-286.

8. Wennerberg A, Albrektsson. T Effects of titanium surface topography on bone integration: a systematic review. Clin Oral Impl Res 2009; 20(s4): 172-184.

9. Wennerberg A, Albrektsson. T On implant surfaces: a review of current knowledge and opinions. Int J Oral Maxillofac Impl 2010; 25: 63-74.

10. Feine JS, Carlsson GE, Awad MA, et al.. The McGill consensus statement on overden- tures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24-25, 2002. Int J Oral Maxillofac Implants 2002; 17: 601–602.

11. Attard NJ, Zarb GA, Laporte A. Long-term treatment costs associated with implant-supported mandibular prostheses in edentulous patients. Int J prosthodont 2005; 18: 117-123.

12. Zitzmann NU, Sendi P, Marinello CP. An economic evaluation of implant treatment in edentulous patients – preliminary results. Int J Prosthodont 2005; 18: 20-27.