

Some issues related to evidence-based implantology

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Abstract

This article reviews relevant dental literature to answer some frequent questions related to evidence-based implantology. There are hundreds of implant systems on the market, but the majority lack clinical documentation. Recommended number of implants for full-arch fixed prostheses is four or five in the mandible but at least six in the maxilla. Less expensive implant-retained overdentures make implant treatment available to a greater portion of edentulous subjects. Mandibular overdentures on two implants, and even one implant, have shown excellent long-term outcomes. In the maxilla, less than four implants are not recommended for good results. Single implant restorations have good prognosis, but placement of the implant should be postponed until adulthood. Osseointegrated implants have revolutionized clinical dentistry. However, in a global perspective, implants make up only a small part of all prosthodontic treatment. Knowledge and skill in conventional prosthodontics must be maintained as it will remain the most common part of the specialty.

Key Words: Alternatives to implant treatment, fixed implant restorations, mandibular implant overdentures, maxillary implant overdentures, single implant restoration, single midline implant overdenture

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INTRODUCTION

It is well-established that dental implants have revolutionized prosthodontic treatment. It is therefore no surprise that implants take up a very great part of prosthodontic conferences and dental literature. However, implants make up only a small part of all prosthodontic treatment! An American prosthodontist estimated in 2003 that only 1.5% of teeth being replaced at that time were replaced with implants. The other 98.5% of missing teeth were still replaced with traditional prosthodontic methods.^[1] These values have certainly changed

over the last 13 years but not to any great extent. A decade ago, it was estimated that <0.1% of the world population of edentulous and partially edentulous individuals had received implant treatment.^[2] The rate was probably too optimistic then, and there is no indication that any great change of the figure has occurred over the last few years. In a global perspective, it is clear that complete denture will continue to play a central role in the rehabilitation of edentulism. Implant treatment is inaccessible for the great majority of edentulous subjects, because of, among other things, economic and resource

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factors.^[3] Thus, research, teaching, and specialist training in complete denture prosthodontics must continue and in fact be intensified rather than reduced.^[4] In a similar way, it can be said regarding restoration of partial edentulism that in a global perspective, conventional prosthodontic treatment such as removable and fixed dental prostheses will continue to be predominant.

The aims of this paper are to present a review of relevant literature on some frequent questions related to implant prosthodontics. It is not a systematic review but in the preparation for the presentation at the Hyderabad conference recent literature, including a number of systematic reviews, was searched to gather as good evidence as possible to answer the selected issues.

QUALITY OF DENTAL IMPLANTS

Slightly more than a decade ago, a survey identified 220 implant brands with circa 2000 types of implants produced by about 80 manufacturers. It was concluded that the scientific literature did not provide any clear directives to claims of alleged benefits of specific characteristics of dental implants.^[5] In 2009, there were about 600 implant systems on the market, produced by at least 146 manufacturers.^[6] During the last year, before this survey was done, 27 new dental implant companies surfaced in the market. A problem is that the majority of the implant brands available have no clinical documentation. Some of them refer to animal testing, but it is well-established that data from animal models cannot predict longitudinal human results. When considering a new implant brand, the clinician should ask for clinical long-term results in human patients. Another problem is that many of the implant systems disappear from the market, which make repairing and maintaining the implants difficult or impossible. There is no evidence that any particular type of implant has superior long-term success.^[7] This statement seems still to be valid.

FIXED IMPLANT PROSTHESES IN EDENTULOUS JAWS

In the book that Dr. Brånemark and his early collaborators presented in 1977,^[8] the edentulous jaw was treated with an implant-supported fixed dental prosthesis (ISFDP). In the book, such a restoration was called a bone-anchored bridge. The main indications listed were (1) insufficient retention of denture because of an extensively resorbed alveolar process, (2) psychic inability to accept a denture, and (3) functional disturbances such as nausea and vomiting elicited by the denture. No alternative to ISFDP was given as it was considered self-evident that patients who had had problems with dentures should have a fixed restoration. In a later book, the indications

were extended to implant overdentures (IODs) and implant treatment in partially edentulous patients.^[9] At present, implant treatment is most common in partial edentulism.

The original Brånemark protocol suggested 6 implants for an ISFDP in both the edentulous mandible and maxilla, with excellent long-term results.^[10,11] The 5-year implant survival of ISFDP has been reported to be about 95%; results that were even higher when studies after the year 2000 were analyzed.^[12,13] In the mandible, the recommendations are now four or five and the reduced number has been shown to give as good results.^[14] Even 3 implants for a mandibular ISFDP have been tried, but only 1-year results have been presented.^[15] In the maxilla, the original recommendation of six implants seems still to be valid. Some authors suggest that the number of implants should be greater (8–12) for “security reasons.” There is no evidence to support this opinion; however, for the manufacturers, it is of course a desirable suggestion. Numerous studies have demonstrated excellent functional results with four to six implants placed in the anterior region for support of full-arch implant-supported fixed prostheses.^[16] Cantilevers make posterior implants unnecessary [Figure 1].

MANDIBULAR IMPLANT OVERDENTURES

IODs have become a common treatment option, and they are in several centers more prevalent than ISFDPs for treatment of patients with edentulous mandibles.^[17]

Mandibular IOD on two implants is a well-established and effective option. Different numbers of implants have been proposed for IODs, but two anterior implants are sufficient.^[18,19] Implant survival has been shown to be as high for IODs as for



Figure 1: Lateral cephalograph showing fixed implant prostheses ad modum Brånemark on six implants in the anterior part of each jaw. No posterior implants but cantilevers supporting the prostheses to the first molar

ISFDPs.^[20] Extremely successful long-term outcome has been documented in a follow-up study: 96% survival rate after 20 years. There was a reduced survival rate (90%) for smokers and one-stage protocol. Bone quality and implant length had no significant impact.^[21] It was concluded that the outcome fully supports the mandibular two-IOD concept also in the long run.

It is sometimes suggested that the presence of antagonistic remaining teeth can affect the success of IODs. A systematic review concluded however that no apparent correlation between the remaining antagonist teeth and the success of the IODs could be found.^[22]

Several retention systems have been described in the literature. For mandibular two-IODs, the implants can be interconnected with a bar or remain unsplinted. The retention to the bar is achieved with a bar-clip attachment. For the unsplinted implants, there are several retention types available, such as ball attachments and magnets. There is no strong evidence for the superiority of one system over the others with respect to patient satisfaction, survival, peri-implant bone loss, and other relevant clinical factors.^[20,23] This means that the choice of retention can be based on the clinician's experience and opinion, preferably after a discussion with the patient on advantages and disadvantages of various options. It must be remembered that all systems with time will require maintenance and repair associated with additional cost. This should be mentioned to the patient at the start of treatment and included in the economic aspects of the treatment.

Early loading of implants has become popular to shorten the treatment time. Several studies have shown that early loading protocols in IOD treatment produce similar results as conventional loading and thus can be a viable option.^[24-26] However, when discussing immediate, early, and conventional loading, it may be prudent to consider the conclusions of a recent systematic review saying that although all three loading protocols provide high survival rates, early and conventional loading protocols are still better documented than immediate loading and seem to result in fewer implant failures during the 1st year.^[27]

SINGLE MIDLINE IMPLANT OVERDENTURE

Economic factors are common obstacles for implants treatment, especially in socioeconomically weak edentulous groups. To reduce the cost is therefore important to increase the use. A way to reduce the cost is to minimize the number of implants. The surprisingly good 5-year results of mandibular overdentures retained by a single midline implant presented already in the 1990s^[28] have promoted a number of studies to evaluate this treatment option, one-IOD [Figure 2; Reprinted

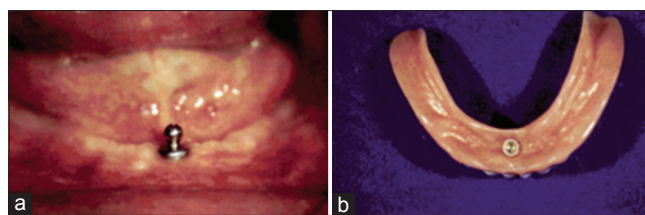


Figure 2: (a and b) Single midline implant with a ball attachment to retain a mandibular overdenture

from Feine and Carlsson^[18] with permission]. Several studies have corroborated the good results with such IODs and recommend them particularly for geriatric patients with low functional demands and economic limitations. A recent 5-year randomized trial compared one or two implants for IODs. No implant failed in the one-IOD group whereas five failed before loading in the two-IOD group. It was concluded that there were no significant differences after 5 years in satisfaction or survival of implants with mandibular overdentures retained by one implant or two implants.^[29] Even more recently, a systematic review and meta-analysis have been published of studies on one- and two-IODs.^[30] "The results of this meta-analysis conclude that the postloading implant survival of one-IODs is not significantly different from two-IODs. However, the existing scientific evidence in the literature in terms of prospective comparative studies is scarce. Hence, before recommending the one-IOD as a treatment modality, long-term observations are needed, and a larger range of functional, prosthodontic, and patient-centered outcome measures should be considered." These conclusions are certainly correct regarding the meta-analysis, but for the clinic, they seem too guarded. It would seem acceptable to recommend more general use of one-IODs as there are several studies already with excellent outcomes over 5 years. It is well-known that a majority of edentulous people belong to the poorest segment of the population, and the single midline mandibular IOD might be a possibility to overcome economic limitations for some of them.

MAXILLARY IMPLANT OVERDENTURES

IODs in the maxilla have not been as successful as in the mandible. Maxillary IODs present a number of different challenges compared to the predictable benefits of mandibular two-IODs.^[31,32] To use a two-IOD in the maxilla cannot be recommended. However, systematic reviews have concluded that maxillary overdentures on four or more implants in a splinted construction provide high survival (>95% for the 1st year) both for implants and overdentures. Long-term results regarding maxillary IODs are still rare and when available often inconsistent.^[33] However, following the recommendation to use four or more implants splinted with a bar system a maxillary

overdenture can be a successful treatment option [Figure 3; Reprinted from Feine and Carlsson^[18] with permission]. Using four or less implants and a ball attachment system is in general less successful.^[20,32]

IMPLANT OVERDENTURE OR FIXED IMPLANT-SUPPORTED PROSTHESIS

At the introduction of osseointegrated implants in Sweden in the 1970s, Professor Brånemark (1977) suggested fixed implant-supported prostheses as the first choice.^[8] This has also remained the policy among prosthodontists in Sweden. The great majority of implant treatments in edentulous mandibles consisted of fixed prosthesis; only a small part was IODs according to two questionnaire studies regarding the years 2001 and 2011.^[34,35] Only small changes had occurred between the two surveys 10 years apart. The same type of questions presented to prosthodontists in ten countries demonstrated a great variation of the use of IODs in the year 2001. In fact, the proportion of IODs to fixed implant-supported prostheses regarding implant treatments of the edentulous mandible varied from 12% in Sweden to 93% in the Netherlands.^[17]

Many factors have an influence on the choice between a fixed and removable implant prosthesis of an edentulous patient, tradition and economy being among the strongest. The great difference between Sweden and the Netherlands may to a great extent be explained by differences in the two countries' dental insurance systems: In Sweden, both fixed and removable prostheses are reimbursed; in the Netherlands, only the removable are reimbursed. At the beginning of the implant era in Sweden, the resources for implant treatment were limited and most of the edentulous patients demanding implants were treated with a mandibular ISFDP and a maxillary complete denture [Figure 4]. In a series of edentulous patients who asked for implant treatment received at first only a mandibular ISFDP and who were told that they might later on come for a maxillary ISFDP. Only a minority of the group (13 of 47) attended for having implants in both jaws.^[36] There was no significant difference in mandibular peri-implant bone loss between those who had a maxillary ISFDP or a complete denture [Figure 5; from Carlsson *et al*^[37]].

IMPLANTS IN PARTIAL EDENTULISM

The original focus in implantology on edentulous jaws rapidly changed after the osseointegration principle had been presented at the Toronto conference in 1982.^[38] Implant restorations began to be used both for single tooth loss and in other types of partial edentulism. In many centers, implant treatment is now much more common in partially than totally edentulous patients. Among the indications for prosthetic intervention with implants in partial edentulism, the

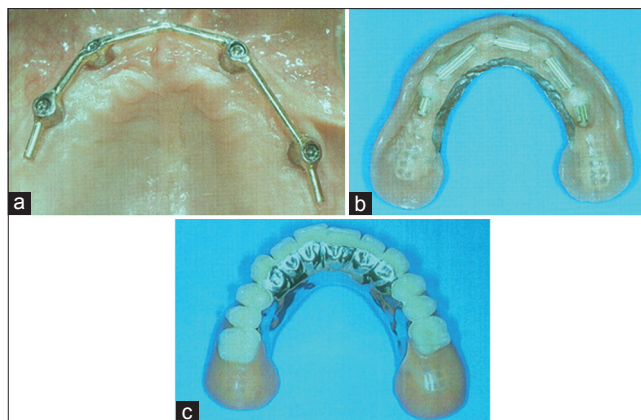


Figure 3: Maxillary implant overdenture with a bar on four implants; (a) inner surface of the overdenture showing the bar retainers; (b) horseshoe type of prosthesis design with open palate. (c) Reprinted from Feine and Carlsson^[18] with permission



Figure 4: Edentulous subject treated (in the 1970s) with a mandibular implant overdenture on six anteriorly placed implants and a complete maxillary complete denture

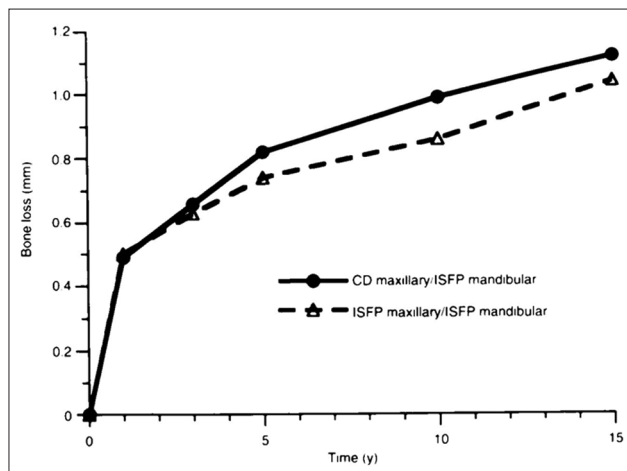


Figure 5: Mean mandibular peri-implant bone loss with respect to prosthetic status in the maxilla. CD = complete denture during the follow-up period of 15 years ($n = 31$); ISFP = Implant-supported fixed prosthesis placed on average after 4.5 years ($n = 13$)

following can be mentioned: (1) Increasing subjective chewing comfort; (2) preserving natural tooth substance or existing

reconstructions; (3) replacement of strategically important abutments; (4) improving esthetical defects after tooth losses.

A patient with a unilateral edentulous area (Kennedy Class II) exhibits all these indications for implant treatment, acknowledging the difficulties with a removable dental prosthesis in such a situation [Figure 6].

The outcome of implant treatment in partial edentulism is as good as in total edentulism; the 5-year survival of implant-supported single crowns, implant-supported FDPs, and implant-tooth-supported FDPs were all close to 95% according to a meta-analysis based on systematic reviews.^[12] The 10-year survival was slightly below 90% for the first two treatments but 78% for the implant tooth restorations. Since many of the studies analyzed in that review were old, a new systematic review was performed comparing results from up to the year 2000 and after that year.^[13] The 5-year survival of implant-supported prostheses was significantly increased in newer studies compared with older ones. This was interpreted as a positive learning curve in implant dentistry. However, the incidence of esthetical, biological, and technical complications remained high, which needs to be noted and discussed both by clinicians and patients already in the decision-making phase of the treatment.

The survival was 95% and the mean marginal peri-implant bone loss was 1.3 mm after a mean of 13.4 years according to a systematic review of longitudinal studies covering more than 10 years.^[39]

An interesting article discussing reasons for failures of oral implants deserves attention. Excerpt of the conclusion: "It may be suggested that the following situations are correlated to increase the implant failure rate: A low insertion torque of implants that are planned to be immediately or early loaded, inexperienced surgeons inserting the implants, implant insertion

in the maxilla, implant insertion in the posterior region of the jaws, implants in heavy smokers, implant insertion in bone qualities type III and IV, implant insertion in places with small bone volumes, use of shorter length, and smaller diameter implants, greater number of implants placed per patient, lack of initial implant stability, use of cylindrical (nonthreaded) implants."^[40]

Here, it might be appropriate to define survival and success, which is crucial when discussing outcome of implant treatment.

Implant survival

- The implant is still in the mouth but not tested or has not necessarily reached the criteria for success.

Implant success

- The implant is immobile when tested clinically
- The radiograph does not demonstrate any evidence of peri-implant radiolucency
- The vertical bone loss should be <0.2 mm annually after the 1st year
- There should be no persistent and/or irreversible signs and symptoms such as pain, infection, neuropathies, or paresthesia.

When reading articles on outcome of implant treatment, it is important to look for adequate use of these definitions.

Single implant restorations

The outcome of implant restoration of single tooth loss is in general excellent with mean 5-year survival of 97%.^[13] Significant differences were found neither for survival and failure rates of metallic and ceramic abutments nor for internally and externally connected abutments.^[41] Different loading protocols have for long been a controversial issue. A recent systematic review concluded however that immediately and conventionally loaded single implant restorations are equally successful regarding implant survival and marginal bone loss.^[42] Another systematic review compared screw- versus cement-retained fixed implant-supported reconstructions and found no statistical difference for survival or failure rates, but screw-retained reconstructions exhibited fewer technical and biologic complications overall.^[43] In contrast, still another systematic review concluded that with inadequate information and various study designs, it was difficult to compare the prosthodontic outcomes between screw- and cement-retained fixed implant prostheses.^[44]

Age is important in treatment with single implants. There is a risk of gradual infraocclusion of the implant-supported crown placed in adolescents.^[45,46] It is therefore recommended today that implant placement should be postponed until

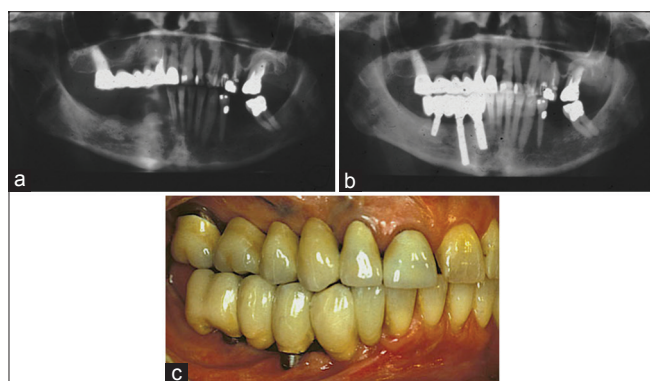


Figure 6: Panoramic radiographs before and after implant treatment in the right edentulous mandible (a and b); clinical view after treatment (c)

adulthood.^[47] Resin-bonded fixed dental prostheses have for long been considered only a temporary option, but more recent studies have documented good long-term results, especially for the 2-unit cantilevered type and when preparations and technical requirements meet the right standards.^[48,49]

Other alternatives to implant restoration of single tooth loss, not to be forgotten, are conventional 2-unit FDPs [Figure 7] and orthodontic treatment. Such therapies deserve to be considered in the decision-making. A problem is that the choice of different treatment options should be evidence-based, which requires controlled clinical research, preferably with randomized controlled trials, which are rare and difficult to conduct. There is therefore still a lack of good evidence for many of the questions to be clearly answered regarding evidence-based implantology.

Alternatives to implant treatment

Oral implants have an enormous potential in prosthodontics, but they cannot solve all problems. There are limitations and all situations cannot be solved. The greatest obstacle is economic. The great majority of edentulous people is poor and cannot afford the high cost of implant treatment. Economy is probably the most important restriction, but there are also direct contraindications:^[50]

- Uncontrolled systemic medical diseases/conditions
- Untreated local jaw pathology
- Substance abuse, including heavy smoking
- Psychological problems
- Unrealistic patient expectations of the implant treatment
- Untreated periodontal disease
- Young age/the growth is not completed

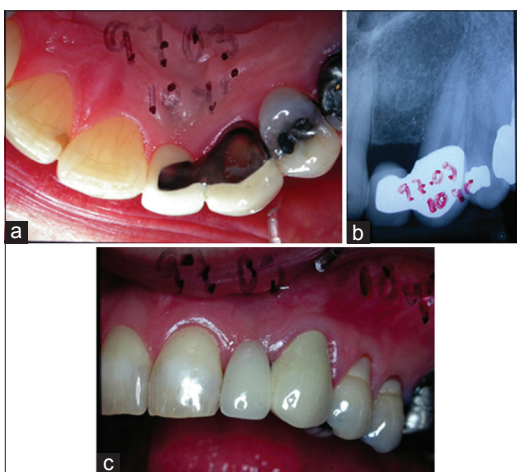


Figure 7: Palatal view of the two-unit bridge (22 pontic, 23 abutment) (a); radiograph of the construction (b); clinical view (c). All pictures are taken 10 years after the insertion of the bridge. Courtesy of Dr. K-G Olsson, Gothenburg, Sweden

- Insufficient bone volume
- Insufficient space between the roots or crowns of the neighboring teeth.

The classical removable and fixed prosthodontic alternatives should not be forgotten when replacing lost teeth! The shortened dental arch concept^[51] should also be included in decision-making in partially edentulous patients.^[52-54]

Although there is a very high survival rate of implant restorations, it is advisable to inform patients thoroughly from the beginning about probable complications as well as expected maintenance requirements and costs to avoid unpleasant confrontations later on. In fact, it has been shown that the rate of complications is greater in implant restorations than in conventional FDPs.^[13,55] The problem with peri-implantitis, although its prevalence is a controversial issue,^[56] must also be included in the evaluation of outcome of implant restorations.^[57,58]

DISCUSSION

This article reviews relevant dental literature to answer some frequent questions related to evidence-based implantology. It is not a systematic review, but it tries to evaluate recent literature to obtain best available evidence of clinical interest. A problem with systematic reviews is that many of them have to conclude that there is not enough strong evidence to draw clear conclusions. The reason given is mainly lack of good enough studies among those found and reviewed. In a summary paper of a consensus conference on “implants and/or teeth,” it was concluded: “In the absence of research of the highest quality, there is a necessity to accept evidence on a lower level to be able to draw any relevant conclusions ... based on the current best available evidence.”^[59] The authors added that the statements and recommendations presented should be regarded as transitory and will require modifications when new results appear. The same can be said of the present review. Hopefully, the information and recommendations presented can be useful for clinicians until new results will change our knowledge base of evidence-based implantology.

CONCLUSIONS

Osseointegrated implants have revolutionized clinical dentistry, and they have an enormous potential in prosthodontics. Even with the rapid and fantastic development in the implant field, which certainly will continue, implants are neither now nor in the near future capable of solving all problems and help all potential patients. The greatest obstacle is economical as edentulous people belong to the poorest segment of the population and only a few can demand implant treatment. It is

therefore necessary to maintain and preferably further develop knowledge and skill in conventional prosthodontics as it will remain the most common and useable part of the specialty in the foreseeable future.

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Conflicts of interest

There are no conflicts of interest.

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