

Implants for the ageing population

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ABSTRACT

Dental implant treatment has established benefits over traditional alternatives. Age-related changes in systemic and oral health in conjunction with social, economic and resource considerations often introduce complexities into dental implant treatment of ageing patients. When time, opportunity, discomfort and maintenance costs are coupled with cost-benefit and quality of life predictions, otherwise simple treatment decisions can become more difficult. Implants for different types of prostheses in both arches and the different types of prostheses themselves present a variety of treatment challenges, risks, benefits and maintenance requirements. This narrative review discusses selective literature pertinent to the provision of dental implant treatment in the ageing population.

Keywords: Ageing, implants, maintenance, patient assessment, risk factors, treatment options.

INTRODUCTION

Successful dental treatment for the ageing population is best approached from an holistic perspective. The influence of chronic diseases; the social, economic and resource characteristics of the ageing population; and age-associated changes in oral tissues present management challenges that require special attention. Limiting factors such as ability to tolerate the required procedures and future access to care, require careful consideration in the planning phase to ensure the proposed treatment is appropriate now and in the future.

BACKGROUND

Dental profile of the ageing population

There is an established association between the mean number of missing teeth and age.¹ Australians aged 65 years and over had a mean number of missing teeth of 12.¹ There was a reduction in edentulism between 1987–1988 and 2004–2006, which continues to the present time due to a change in treatment approach away from full mouth clearance of the 1920–1940s and the passing of older generations that experienced an epidemic of tooth loss.² The prevalence of edentulism has been projected to further decrease to 1% of the total population by the 2040s.²

Coupled with the patterns of tooth loss and the ageing population³ is an ever increasing life expectancy at birth listed at 80 years and 84 years for males and females respectively, as at 2008–2010.⁴ Therefore, a discussion of implant treatment in the ageing population can no longer be limited to edentulous treatment options, rather the full range of options, some of which might only have been considered in younger populations in previous times.

Treatment with dental implants

Dental implant treatment has evolved over time from the use of subperiosteal, transosteal and endosseous plate (blade) form implants to endosseous root form implants that have become the mainstay of modern day implantology (Fig. 1). The first titanium dental implants were placed by Per-Ingvar Brånemark in edentulous mandibles with long-term success established and reported.^{5,6} The restorative aspect of implant dentistry is now widely practised in the dental profession and in the US was the only prosthodontic procedure that increased per capita from 1992 to 2007, where the peak age for placement of implants was between the ages of 60 and 75 years.^{7,8}

Suitably planned and managed dental implant treatment has established and accepted benefits over more traditional options. However, dental implant treatment is considered expensive, usually involves long

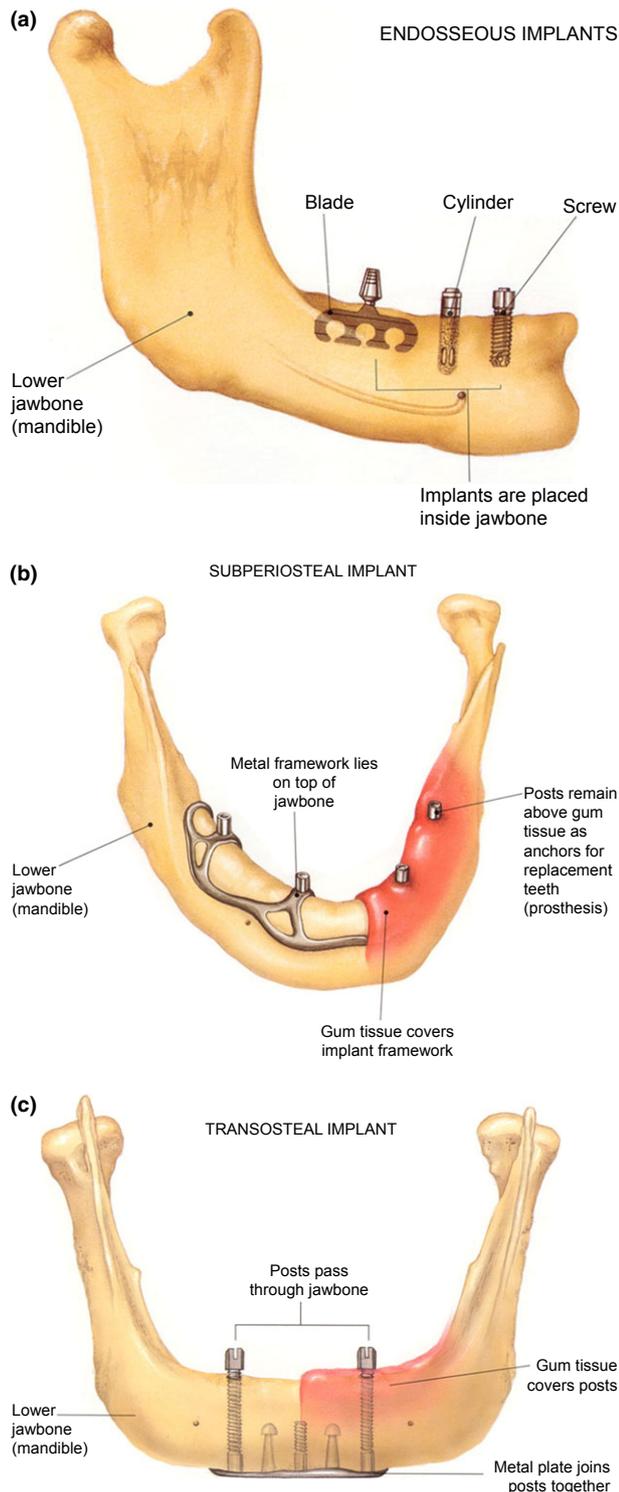


Fig. 1 (a) endosseous, (b) subperiosteal and (c) transosteal implants (Source: University of Connecticut Health Center. Center for Implant and Reconstructive Dentistry. Types of dental implants. URL: '<http://dental-implants.uhc.edu/about/types.html>'. Accessed March 2014.)

treatment times and requires patients to undergo the necessary surgical and restorative procedures over multiple appointments.

IMPLANT CONSIDERATIONS

The age related implant literature

There is a paucity of scientific evidence that reports specifically on implant dentistry for aged patients,^{9–12} i.e. patients aged 65 years and over.¹ A limited number of dental implant studies have solely and specifically set out to investigate the variable of ageing.^{10,11,13,14}

Age is one of the measurements obtained routinely within implant studies investigating other parameters along with gender, implant site, number of patients treated and implant type. Interestingly, age is often one of the first variables reported, yet appears to attract minimal commentary.

Age and surgical implant placement

In a literature review of implant dentistry for aged patients where similar implant survival rates were cited in older and other age groups, it was concluded 'old age is not a contraindication for implant therapy, however, clinicians should be aware of potential risks, possible medical complications, and psychosocial issues that affect implant prognosis in geriatric patients'.⁹ A separate review of nine studies reporting on dental implant treatment in aged patients determined that treatment with implants could be considered safe and predictable for older as well as younger patients and 'patients' age does not seem to represent a factor of major prognostic significance'.¹⁰ In a far reaching review of dental literature on evidence-based treatment planning for dental implants, there was no scientifically proven contraindication for the placement of implants based solely on increasing age.¹⁵

In a comparison between closely matched groups of 190 implants in 39 patients aged 60–74 years and 184 implants in 43 patients aged 26–49 years, each with similar types of prostheses observed for 4–14 years, no statistically significant difference in implant survival was observed, although in looking purely at the percentages the older patient group in fact performed better.¹⁴ Despite the implant findings, the 'average health' of the younger group was better compared with the older group.¹⁴ A variety of prostheses including single crowns, short-span prostheses, complete-arch prostheses and removable overdentures were involved in this particular study, and it was proposed implant survival was independent of the type of prosthesis.¹⁴ The authors also cited five studies that reported a 94–97% implant success rate in older patients and a 88–99% success rate in younger patients.¹⁴ On the basis of this evidence, it could be proposed that implants are more successful in older patients but the included studies suffer from a short

follow-up period and the absence of matched control groups of younger adults.¹⁴

The observation of equal or better implant survival in older populations compared with younger populations was agreed upon by other authors with poor oral hygiene being noted as the most common complication.^{16,17} In further studies comprising significant numbers of implants placed for a variety of different prostheses in aged patients, some of whom had compromised general health, there was no correlation of age or medical status with implant survival.^{18–21}

A 96% implant success rate was reported in a study of 48 patients who were more than 80 years old treated with a total of 254 implants for bridges and some overdentures.²² Most patients had minimal post-implant placement problems, similar in nature to those observed in younger patients.²² The marginal bone response around the neck of the implant demonstrated a pattern of modelling and remodelling similar to that found in younger age groups.²² It was concluded that 'no patients should be refused implant treatment because of advanced age'.²²

The Toronto Study in 1994 concluded that neither advanced age itself nor the diminished levels of oral hygiene that often accompany it, are alone contraindications to 'a prescription for treatment with osseointegration'.^{23,24} In an early review of factors contributing to implant surgical success it was concluded that 'in principle there are no specific contraindications for implant surgery, as long as other kinds of oral surgery can be performed'.²⁵

All of the studies described to this point used a single type of implant within their study. In a study of three different endosseous implant types (a titanium plasma-sprayed cylinder, a titanium cylinder implant with hydroxyapatite coating, and standard threaded titanium) inserted in the anterior mandibles to support overdentures for 15 patients aged 65 to 80 years without serious systemic diseases, no implant failures were reported during the follow-up of three years.²⁶

While the current review does not propose to consider the different implant types and surfaces used over time, one issue faced in comparing older and more recent studies is that older implants were predominantly turned ('machined') surfaces which were smoother in comparison to the modern day moderately roughened implants.²⁷ The bone response to moderately roughened implants has been found to be significantly stronger than the bone response to smoother or rougher surfaces.²⁷

The 'All-on-Four' protocol using tilted implants has provided additional alternatives for the restoration of posterior segments of the mouth without grafting and has been described as predictable.²⁸ In a review of 800 implants, a cumulative implant survival rate of 97% was reported for both axial and tilted implants

assessed three months post-surgery after immediately loaded all-acrylic resin interim prostheses were constructed.²⁸ Age, amongst other factors was not a significant parameter.²⁸

Mini-implants, defined as implants less than 3 mm in diameter, have been recommended in implant treatment for aged patients as they can be placed in narrow ridges to reduce the need for grafting, offer simplified clinical procedures almost always involving flapless placement (potentially offering less traumatic surgery), offer potential for immediate loading, and are less expensive than small diameter implants for reasons that remain unclear.²⁹ Despite mini-implants offering the clinician simplified treatment procedures without a steep learning curve, the available literature is scarce.²⁹ In a systematic review of the mini-implant literature, it was not possible to establish the true one-year survival rate as the minimum follow-up period for many implants within the included studies was less than one year and the authors concluded that currently there is no evidence for the long-term survival of mini-implants.²⁹

Common themes

Despite the shortcomings of some studies, the literature overwhelmingly supports implant treatment in aged patients. Older age groups were equally successful, and in some studies more successful than younger groups. However, the pertinent literature is generally old and often reports on implant types and surfaces no longer routinely used in modern day implant dentistry. One potential reason for the lack of more recent literature is that few older studies found significant differences in implant survival in different age groups, hence it became accepted that aged patients could reliably and predictably receive dental implant treatment and studies moved on to focus on more complex and perhaps more topical issues.

The reported implant survival rates are generally 90% or more but significant limitations are the short follow-up times (of varying durations), small sample sizes in some studies, variations in location of implant placement within jaws and the variety of different prostheses constructed, thus limiting the effectiveness and appropriateness of interstudy comparison.

The prostheses included are almost exclusively full-arch fixed or removable prostheses which are indicative of the type of treatment carried out for ageing populations in the era of observation. Some early studies claimed that implant success was independent of the type of prosthesis.

Implant survival and success appeared to be used interchangeably in different papers largely due to ease of measurement and a lack of consensus in defining and measuring implant success. The patient's medical

status was not always reported. Oral hygiene tended to be an issue in aged patients receiving implant treatment but it was thought to be manageable by a period of cleaning and regular maintenance.

Conflicting evidence

In a study of risk factors for implant failure, the outcomes of 4680 implants placed in 1140 patients were reviewed and it was found that patients in the 60–79 years age group (18% failure rate) had a significantly higher risk of implant failure than patients younger than 40 years (9% failure).³⁰ The study is limited by the fact that a single operator performed all the implant surgery where interestingly one patient received a total of 24 implants.³⁰ The author concluded that there are no absolute contraindications to implant placement.³⁰

In a seven-year multicentre longitudinal study of 1022 consecutively placed ITI implants it was noted the cumulative implant success rates for implants placed in patients aged over 60 years was 78% compared to patients aged less than 40 years (83%) and patients between 40 and 60 years (89%).³¹ The use of implant success criteria (instead of implant survival) in this study explains the lower success rates.³¹

In a study of 68 patients treated with 204 implants (predominantly supporting overdentures) followed-up over 4–60 months, the possible reasons why 6% of implants failed to integrate were primarily due to overheating during surgery and secondarily the advanced age of two patients and poor general health of one patient.³² The age profiles were not reported and therefore it is difficult to draw conclusions.

The conflicting evidence is scarce and generally less convincing of a negative effect of increasing age on implant treatment. One shortcoming of all age-related studies is the difficulty in isolating age as a specific causative factor for the observed failures, where undiagnosed or subclinical general health conditions may underlie age and contribute to implant failure yet be impossible to identify and measure.

Medical conditions influencing implant treatment

In 2004–2005, 32% of the 65 years and over age group reported one chronic medical condition, with 23% reporting three or more chronic medical conditions.³³ The 11 chronic diseases and conditions that were listed as having a large impact on the health and quality of life of Australians were coronary heart disease, stroke, lung cancer, colorectal cancer, depression, diabetes, asthma, chronic obstructive pulmonary disease, chronic kidney disease, oral diseases, arthritis and osteoporosis.³⁴

Specific medical conditions (and their associated treatments) more commonly encountered in the ageing population often necessitate further investigation, consultation and management strategies prior to considering implant treatment. Undiagnosed systemic conditions represent a further challenge and it is for the astute clinician to recognize oral signs of systemic disease and arrange appropriate further investigation.

Different medical conditions pose different levels of risk to implant procedures. The more commonly encountered medical conditions have been differentiated into absolute and relative contraindications in an attempt to differentiate risk.^{15,35}

Absolute contraindications preclude implant treatment and are usually obvious because treatment is clearly inappropriate, impossible or risks patient survival. They include conditions such as recent myocardial infarction, recent cerebrovascular accident and significant psychiatric disorders.³⁵ It should be noted that patients in this category do not contribute to the reported success, survival or failure rates in the literature because they do not undergo implant treatment.

Conversely, relative contraindications do not automatically preclude implant treatment but warrant careful assessment in the planning phase.³⁶ It is important to consider the precise diagnosis, time since diagnosis (or more accurately time since onset), management (and degree of success with management), severity of the condition and potential impact of the medical condition on the planned implant procedures. While individual relative contraindications may not preclude implant treatment, combinations of relative contraindications, termed the cluster phenomenon, may collectively equate to an absolute contraindication.^{15,37}

In a review of a number of systemic host factors including age, gender, various medical conditions, patient habits and local host factors, it was advocated that ‘no systemic factor or habit is an absolute contraindication to the placement of osseointegrated implants in the adult patient’.¹⁵ However, certain individual factors and combinations of factors may be associated with increased risks of implant failure.

Physiological and pathological ageing

Ageing has been differentiated into physiologic and pathologic.³⁸ Physiological ageing refers to physical, metabolic and endocrine changes associated with ageing whereas pathological ageing refers to specific medical conditions that require careful consideration when considering implant treatment.³⁸ It is important that clinicians are aware of the physical, metabolic and endocrine changes associated with ageing, and how these changes may affect implant treatment.³⁹

Osteoporosis

Osteoporosis is a systematic disease that results in a decrease in bone mineral density and bone mass that is almost unavoidable during ageing. The prevalence of osteoporosis increases with age and is more prevalent in females than males.⁴⁰ The age range of 25–30 years has been reported as the time at which bone mineral density reaches its peak following which osteoclastic activity exceeds osteoblastic activity.^{38,41–43} Osteoporosis diagnosed at one particular site of the skeleton is not indicative of osteoporosis at other locations, which is logical as different bones at different locations are subject to different stresses which in turn influences remodelling.⁴⁴

Osteoporosis has not been established as a risk factor for successful osseointegration of dental implants.^{9,15,36,44} If there was a direct correlation between osteoporosis and osseointegration, then the rate of implant loss caused by osseointegration failure would increase relative to age and gender.⁴⁴ The anterior mandible has been reported to not experience significant age-related osteopenia which is an important factor when considering implant treatment for aged patients.^{14,23,45}

The use of bisphosphonate medications to slow osteoclastic activity in an attempt to slow the rate and severity of age-associated bone loss may have a deleterious effect on implant survival.^{46,47} However, the magnitude of the effect is dependent on the type of medication, route of administration and duration of use.^{46,47}

The observations of dental implant treatment in the ageing population are consistent with the orthopaedic literature that has established the efficacy of hip prostheses.¹¹ Even though there is a decline in the capacity for fracture repair with increasing age, the effect of osteoporosis on fracture repair is currently unfounded.^{48–50} Therefore, patients should not be denied dental implant treatment on the basis of a diagnosis of osteoporosis (or reduced bone mass), rather an assessment of the local site of planned implant placement, ideally by direct vision, appears the most appropriate form of management.^{15,51}

Menopause

In females, menopause is associated with reduced oestrogen levels that are in turn associated with increased bone resorption.³⁸ Males are not immune from this process, with loss of bone mineral density starting after the age of 70 at a similar rate to females.^{38,52}

Despite post-menopausal women having an increased risk for osteoporosis, oestrogen status is a concern with implants in the maxilla but not the mandible.^{36,53,54} In one particular study, post-menopausal

women receiving oestrogen therapy (as distinct from post-menopausal women not receiving oestrogen therapy) were correlated with a significantly increased failure rate, but it was stated that confounding factors may be present and further research was needed.³⁰ A clear majority of studies have found that gender does not affect implant failure rates.^{15,55}

Bone quality and quantity

It has been stated that ‘the most important local patient factor for successful treatment is the quality and quantity of bone available at the implant site’.¹⁵ By bone quality, bone density is implied.

Many different classifications of bone type and jaw shape have been proposed but one of the most universally accepted differentiates bone into four types, determined by different bone composition, and five shapes according to the degree of resorption post-extraction (Fig. 2).⁵⁶ This classification was primarily instituted using a subjective assessment of panoramic and cephalometric radiographs.¹¹

Bone quality is one reason for the differences in implant success at different sites of the mouth. A 12–16% implant failure rate in type 4 bone compared to 4% in types 1–3 has been reported.^{57–60} Other research has reported two and three-fold increases in implant failure rates in the maxilla compared with the mandible.^{30,53}

Some sources have proposed a combination of bone volume and density is the most significant factor for implant success.⁶¹ A review of biological factors contributing to failures of osseointegrated implants found partially edentulous patients had failure rates about

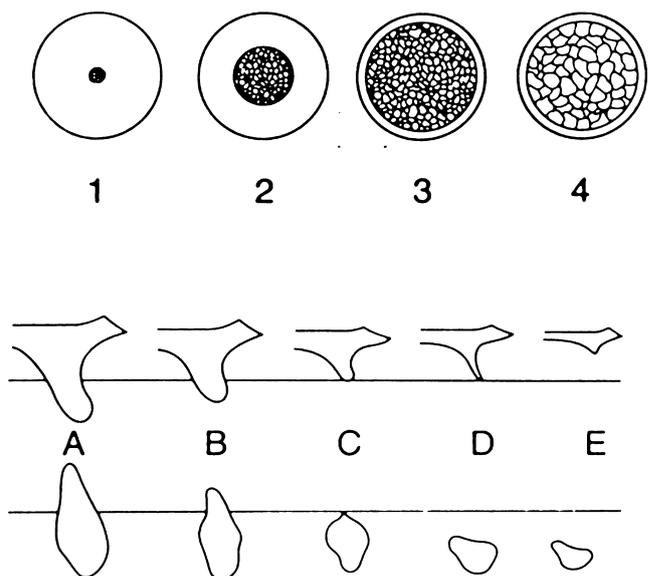


Fig. 2 Classification of jaw bone quality and shape.⁵⁶

half those of totally edentulous patients, explained by partially edentulous patients having less resorbed jaws and better bone quality.⁵³ Increased implant failure rates have been found in sites of combined low bone volume and type 4 bone, a presentation more likely to be encountered in aged patients.^{11,15,62,63} It is generally accepted that older patients have longer healing times, and hence potentially require longer times for osseointegration.^{15,38,53}

Primary implant stability has been established as an important criterion for implant success.⁶⁴ The degree of primary implant stability and a failure to achieve primary implant stability showed the strongest association with the site of implant insertion but were not associated with age.^{60,65} The quality and quantity of bone are best assessed preoperatively using three-dimensional volumetric tomography and again directly at the time of surgery.^{15,37}

Specific conditions

It is not the purpose of this review to comprehensively review the medical conditions encountered in the ageing population that may influence implant treatment. The literature is divided on whether some medical conditions found more frequently in aged patients represent contraindications for dental implant treatment.

In some research, medical conditions such as diabetes, cardiovascular disease, steroid therapy, chemotherapy and head and neck radiation have been established as relative contraindications for dental implant treatment.^{30,66–69} Other research has found that individual medical conditions do not correlate with increased rates of implant failure, rather implant success is largely dictated by bone quality and quantity, and surgical technique.^{19,30,68,70–75}

Oral hygiene

There is a preconceived perception that older patients have poorer oral hygiene. While it could be expected that the ability to maintain good oral hygiene declines with age, it has been found that successful osseointegration can be achieved irrespective of the patient's oral hygiene.^{9,13,15,23,55,76}

Poor oral hygiene has been associated with bone loss and peri-implant disease which if left unmanaged can lead to implant failure.^{77,78} It was demonstrated in an evaluation of 1692 implants that the failure rate of implants was significantly higher in patients subjectively evaluated with insufficient oral hygiene.⁷⁹ As in periodontitis, it is likely that the process of bacterial accumulation around implants and its subsequent level of tissue destruction is markedly influenced by individual susceptibility and host response mechanisms.

RESTORATIVE CONSIDERATIONS

The restorative requirements of dental implant treatment for aged patients range in complexity from straightforward, minimally time consuming processes to complex procedures requiring multiple lengthy appointments and high levels of patient compliance. For all cases, irrespective of age, implant treatment should be a restoratively driven process.

While the goals of maximizing comfort, function and aesthetics remain prime treatment objectives, an important interplay of social, economic and time factors; individual assessment of maintenance requirements; risk of complications; and adaptive capacity exist in the ageing population. The following discussion of the restorative considerations for implant treatment is divided into the types of implant prostheses encountered most frequently in the ageing population in accordance with reports in the literature.

Single and multiple tooth replacement

Fixed prostheses

Single tooth implant supported crowns have established benefits over treatment alternatives. A report on long-term prospective and retrospective cohort studies found the survival rate of implant supported single crowns was comparable to or exceeded that of conventional fixed restorations after 5 and 10 years follow-up.⁸⁰ In considering the findings from the literature reviewed in the first section of this paper that established implants can be placed successfully in healthy aged patients without additional risk compared with younger populations, it would appear that implant treatment to replace single or multiple missing teeth in appropriately planned cases is the first treatment of choice.

There is agreement in the literature that dental implant treatment has a high success rate, although different methodologies tend to limit interstudy comparisons.^{57,81–84} But the same studies present a common theme of a higher level of complications when compared to tooth-supported prostheses.^{57,81–84}

At first glance, a survival rate for implant supported single crowns and implant supported fixed prostheses (replacing more than one tooth) of 95% at five years appears favourable.⁸⁰ At 10 years, a survival rate of 87% for implant supported fixed prostheses and 89% for implant supported single crowns is still very good.⁸⁰ However, during the five-year observation period, 39% of patients with implant supported fixed prostheses (replacing more than one tooth) had some complications, substantially higher than the 16% complication rate reported for tooth-supported prostheses.⁸⁰

In the aged population, the need to attend and re-attend for expected or unexpected maintenance events may lead some patients towards a different treatment option. Therefore, a realistic dilemma exists in whether a single implant supported crown is in fact the best option for aged patients at the current time and over the next 10–20 years when there may be future predictable changes in manual dexterity, oral hygiene, mobility and ability to attend for maintenance and/or complications.

Removable prostheses

Removable partial dentures, particularly with free-end saddles, are frequently problematic for patients, particularly for those with poor adaptive capacity. The use of implants to improve retention and/or reduce rotational movement of mandibular removable partial dentures has consistently provided greater patient satisfaction scores.^{85–87} High maintenance requirements of mandibular implant supported removable partial dentures have been reported, with up to 58% of patients requiring further prosthodontic repair within the first year of function.^{87,88} Although this treatment modality may be a low cost and beneficial alternative, the evidence is limited and only available in the short term.⁸⁷

Edentulous patients

Historically, older patients have been frequently treated with removable dentures. Clinicians have been remarkably successful in treating edentulous patients with complete dentures; however, there remain a large number of patients with varying degrees of success and a sub-group with no success at all who are a challenge to manage.^{9,10,89} Patients and clinicians often disagree about what constitutes a successful denture experience.²³ It has been established that tooth loss and denture wearing results in a decrease in dietary adequacy and an inferior diet compared to dentate people.⁹⁰

Edentulous mandible

Removable complete dentures often present treatment challenges for the clinician and management issues for the patient. Dental implants can be utilized to assist with stabilization of removable complete dentures or alternatively to support a fixed implant prosthesis.

Overdentures

The advantages of mandibular implant overdentures have been well established and include aspects of functional, structural and psychosocial gain.^{91–93} The

literature contains a large volume of supportive evidence for this treatment modality.^{94–99} Dental implants also assist in maintaining bone volume, thus resisting the rapid alveolar resorption patterns seen with removable partial dentures and to a lesser extent in dentate and edentulous sites.¹⁰⁰

In a systematic literature review of 17 studies (including four randomized controlled trials), the survival of implants predominantly involving two implants supporting a removable overdenture ranged from 93% to 100% at 10 years.¹⁰¹ One included study pooled a variety of different overdenture designs, attachment types and numbers of implant and locations and reported a mandibular implant survival rate of 95% after 10 years.¹⁰²

Clinicians may believe a greater number of implants provide better results; however, the literature is un-supportive. Although two implants placed bilaterally in the interforaminal region of the mandible appears to be the most accepted protocol, one, three and four implants have been proposed. The number of implants used to support an overdenture is not associated with different implant survivals, patient satisfaction or overdenture maintenance.^{101,103–105}

Patients have reported greater prosthesis satisfaction and masticatory capacity with mandibular implant overdentures compared to conventional full lower dentures over periods of 10 years.¹⁰⁶ Other studies have concurred with these conclusions irrespective of the number of implants used,^{99,107–109} including a recent systematic review.¹¹⁰ The conversion of existing mandibular dentures to implant supported overdentures was reported to provide significant improvements in oral health (as measured by the OHIP-20 profile) when compared to relining existing mandibular dentures in dissatisfied denture wearers.¹¹¹

In a multicentre randomized clinical trial, one group of patients was treated with mandibular implant supported overdentures and a new maxillary denture, and another group with a new set of complete dentures.¹¹² It was established that the mandibular implant supported overdentures provided greater satisfaction with regard to denture related problems.¹¹²

In a study of 34 patients aged 75 years or over who depended on help for daily living activities, patients were randomly assigned to receive two mandibular implants to support an overdenture or a relined conventional mandibular denture.⁹³ In the patients who received the mandibular implant overdenture treatment, an increased oral health-related quality of life was reported; however, chewing efficiency was no different between the groups.⁹³ The insertion of the mandibular implant overdenture was noted as problematic for some patients and their caregivers due to the nature of the Locator[®] attachments, and in two

cases the attachments were replaced by attachments that permitted easier insertion.⁹³ This is an important consideration for patients who may not have the physical capacity to maintain appropriate oral hygiene or who suffer from muscle weakness-related conditions such as arthritis.

It has been established in the literature and observed in clinical practice that there is a reduction in the patient compensatory ability for the functional shortcomings of complete dentures with increasing age.⁹³ Studies that investigate various treatments in ageing populations are not necessarily able to make generalizations about the ageing age group as a whole, when there is a difference in adaptive capacity in 'young old' patients (less than 70 years) compared with 'old old' patients.⁹³ High success rates of mandibular overdenture treatment have been reported in patients older than 80 years but importantly the patients were mostly living independently.^{13,93}

The initial success of mandibular implant supported overdentures lead to the construction of the McGill Consensus Statement that proposed a two implant supported mandibular overdenture should become the 'first choice of treatment for the edentulous mandible' and the 'first choice' standard of care.⁹⁶ More recently, the York Consensus Statement reinforced the concept that a 'two implant supported mandibular overdenture should be the minimum offered to edentulous patients as a first choice of treatment'.^{97,98}

The term 'standard of care' emanates from claims of negligence and malpractice, and assumes a duty of care owed to the patient was violated.¹¹³ A standard of care does not imply a particular treatment regimen nor that anything less is inferior and therefore negligent.¹¹³ A consensus statement is different to a standard of care. Clinically relevant consensus statements should assist clinicians with decision making but at times fail to acknowledge individual patient variations and the difficulties faced in countries where significant access and economic barriers exist in providing effective dental treatment. Successful clinical treatment that fails to abide by a consensus statement may incorrectly be construed as substandard.

Clinicians should take great care to avoid applying a single treatment concept to all edentulous mandibles, when obvious individual patient circumstances require careful assessment and consideration.^{114,115} Clinicians who have provided traditional (non-implant supported) full lower dentures to patients who have expressed satisfaction with the final prosthesis may rightly argue that they have not fallen short of providing the 'minimum standard of care as a first choice of treatment' as recommended by the McGill and York Consensus Statements.¹¹⁴

The multifactorial nature of implant overdenture treatment was highlighted in a study by Walton and

MacEntee¹¹⁶ where 36% of edentulous participants declined an offer of free implant treatment to support their mandibular dentures. The most common reasons for refusal were satisfaction with their current dentures and a fear of the surgical requirements and subsequent treatment.¹¹⁶ A similar observation was found in a separate study where 7 of 23 participants declined the opportunity to receive two implants to support their existing mandibular denture for reasons of fear of surgery, pain or unperceived need for improvement.⁹³

Overdenture maintenance

Mandibular implant overdentures require variable degrees of maintenance at different stages of the prosthesis lifespan.^{94,101,117} Although there are established differences in the retentive strengths of various designs such as ball, bar and clip, and Locator[®] attachments, there is a lack of conclusive clinical evidence that demonstrates the overall superiority of one particular system over another.^{101,117-119} No particular attachment system is associated with greater implant survival¹²⁰ or greater patient satisfaction.^{94,101,117}

When compared to mandibular complete dentures, more aftercare was needed for patients with mandibular implant supported overdentures.^{110,121} The choice of attachment system is important in patients who may have difficulty with maintaining sound oral hygiene as individual Locator[®] attachments have been associated with a reduced prevalence of *Candida albicans* and denture-related stomatitis when compared to bar attachments for mandibular implant overdentures.¹²²

Fixed prostheses

An alternative to the mandibular removable overdenture is a fixed prosthesis supported exclusively by at least three implants without mucosal support. A high implant survival rate has been established for mandibular fixed implant prostheses regardless of the loading protocols.^{6,28,123-126}

A 99% cumulative implant survival rate over five years has been reported for mandibular fixed prostheses in patients older than 80 years.¹²⁷ In the Toronto study involving the treatment of maladaptive complete denture patients with mandibular implant supported fixed prostheses, 'every patient reported considerable satisfaction with the prosthetic result achieved' and 'previous complaints disappeared almost immediately'.¹²⁸

Fixed prosthesis maintenance

It has been stated that 'the prosthetic and surgical problems and complications encountered with

geriatric patients are similar to those reported in younger patients'.⁹ In a study of 264 patients mostly treated with mandibular fixed implant prostheses, an 86% overall prosthesis survival rate at 20 years was reported.¹²⁹ However, this figure included significant 'anticipated' and 'unanticipated' prosthetic and implant complications and further analysis revealed a 50% complication rate at 5 years, 65% at 10 years and 89% at 20 years.¹²⁹ In a systematic review of complications with fixed implant rehabilitations, when data from maxillary and mandibular fixed implant prostheses were pooled only 29% of prostheses at 5 years and 9% of prostheses at 10 years remained free of complications.¹³⁰

It is difficult to accurately and specifically predict future maintenance events and complications for individual patients. Collectively, maintenance, complications, potential for retreatment and prosthesis lifespan constitute significant future management considerations for aged patients pursuing implant treatment in the mandible. Due to the reported high frequency of maintenance and maintenance requirements, mandibular fixed prostheses may be inappropriate for some aged patients and alternatively, more easily maintained treatment options may require consideration.

Comparisons

It may be thought that mandibular fixed prostheses provide greater levels of masticatory efficiency than removable overdentures because they resist movement. In an interesting comparative study investigating the masticatory function of patients who wore mandibular removable and fixed implant prostheses, eight patients received a fixed prosthesis and seven received a removable overdenture supported by a long bar.¹³¹ Part way through the study, each patient was fitted with the other type of prosthesis.¹³¹ The patients who wore mandibular overdentures reported a shorter mastication time for all foods.¹³¹

Lower costs have been associated with mandibular overdentures when compared with mandibular fixed prostheses over nine years of function.^{132,133} Two implant supported mandibular overdentures have been established as a more cost-effective treatment option for patients with an edentulous mandible when compared to four implant supported prostheses.⁹⁹ The costs associated with two implant supported mandibular overdentures were reported as almost three times higher than conventional dentures and for four implant supported overdentures six times higher.⁹⁹

Mandibular implant overdentures have been reported as more cost-effective than fixed implant prostheses for maladaptive denture wearers.¹³² Patients seeking a fixed prosthesis need to invest more money initially and in the maintenance phase of treat-

ment, and often require a longer time for treatment compared with mandibular implant overdentures.¹³²

Edentulous maxilla

Although the maxilla has been traditionally regarded as the easier of the two arches to treat with complete dentures, the same cannot be said for implant treatment. As with mandibular complete dentures, maxillary complete dentures can present problems frequently related to retention, stability and the need for palatal coverage that are difficult for patients to manage. Restoration of the edentulous maxilla using implants is a complex and challenging procedure that requires meticulous planning.¹³⁴

Overdentures

Two frequently proclaimed benefits of maxillary overdentures are aiding prosthesis retention and facilitating a reduction in palatal coverage.^{118,135,136} Additionally, the capacity for easy and frequent prosthesis removal to facilitate oral hygiene is an attractive feature for some cases and patients.

Inherent problems exist with maxillary implant overdentures as evidenced in the limited available literature.^{114,137,138} Maxillary overdenture implant survival rates are the lowest of all implant prosthesis types and have been reported as low as 71% at five years.^{57,118}

In a systematic literature review¹⁰¹ (including only four suitable studies, none of which were randomized controlled trials) investigating implants generally involving four to six implant maxillary overdentures, the implant survival rate was 75% after seven years in the one study that reported maxillary implant survival.¹³⁹ Two other studies reported an implant success rate of 72% after 5 years¹⁴⁰ and 84% after 6 years,¹⁴¹ and the final study pooled maxillary and mandibular implant data.²⁴ A distinct lack of evidence for observation periods of 10 years or more was noted.¹⁰¹

Overdenture maintenance

High prosthetic maintenance requirements have been reported for maxillary implant overdentures when compared with mandibular implant overdentures but have been difficult to standardize.^{95,101,114,118} The limitations in vertical space for prosthetic components may be an important explanatory factor.¹⁰¹ In contrast, and as an indication of the lack of clarity in this area, a systematic review found comparable prosthetic maintenance requirements existed for implant overdentures in the maxilla and mandible; however, this finding appears to be in the minority.¹¹⁹

The first specific systematic literature review of maxillary implant overdenture maintenance requirements established the maintenance requirements were a 'direct consequence of the attachment system'.⁹⁵ Although ultimately dictated by clinician preference rather than the scientific evidence, unsplinted implant attachment systems may offer greater ease for hygiene and greater ease for maintenance or repair than splinted attachment systems.^{94,114,136,137} In accordance with mandibular implant overdenture literature, there is no particular attachment system that demonstrates superiority over others for maxillary implant overdentures.¹⁰¹

Fixed prostheses

Alternatively, a prosthesis may be constructed that is generally attached to four or more implants in the maxilla. The provision of maxillary fixed prostheses for any population group is a particularly complex treatment necessitating thorough and precise planning with high levels of patient compliance.

Although also of importance with maxillary overdentures, maxillary fixed implant prostheses require additional careful and strategic assessment of the following aesthetic parameters that are crucial to the success of the treatment: facial form in three dimensions; lip position in repose and smiling; lip tonicity; tooth alignment; incisal edge position; gingival display; potential lip support (potentially necessitating a labial flange best provided by an overdenture); and speech.^{134,142} Collectively, these factors necessitate precise implant placement which can be assisted by three-dimensional volumetric tomography in conjunction with treatment planning software programmes. A change in treatment plan from a removable to a fixed prosthesis necessitated by suboptimal implant positioning, implant failure or a failure to recognize initial limiting factors may be disappointing for the patient and problematic for the clinician.¹³⁴

Favourable implant survival rates have been reported for implants placed for fixed prostheses in the maxilla, irrespective of the loading protocol.^{57,143–146} In instances of single implant failure, fixed prostheses can survive either on the remaining implants or on replacement implants, but in some instances require conversion to removable overdentures supported by the remaining implants.^{124,144–146} The established high failure rate specifically for maxillary overdentures adds an additional dimension to cases converted to removable overdentures.^{57,101,118,139–141}

Fixed prostheses maintenance

In a meta-analysis of prosthodontic complications of fixed implant prostheses in edentulous patients, a

cumulative 67% veneering material fracture rate and 44% material wear over 15 years was reported for combined maxillary and mandibular prostheses.¹⁴⁷ The authors commented that 'in the hands of experienced operators, complications occur frequently enough to concern clinicians of lesser experience'.¹⁴⁷

A 15-year follow-up of 76 consecutive patients (with a mean age of 60 years) provided with fixed implant prostheses in edentulous upper jaws established a 91% implant and prosthesis cumulative survival rate although a high loss to follow-up was reported due to the age at first surgery.¹⁴⁶ The most frequent problem encountered was resin veneer fracture up to 10 years, then severe wear in the 11–15 year interval.¹⁴⁶ This study highlighted a significant limitation in ageing population studies of a high loss to follow-up due to patients changing location, moving into care facilities, sickness and death.

Maintenance requirements for fixed implant prostheses can be time consuming and costly, and are important considerations for prospective patients. Importantly, prosthesis complications do not tend to affect implant survival. Patients may also need to be without their prosthesis for some time while the repair and maintenance work is carried out, and for this reason it is important that retrievability is built into prosthesis design. Maintenance and repair procedures may be challenging for patients with fixed implant prostheses with limited mobility or in nursing homes, and consideration should be given to providing removable prostheses with individual implant attachments that facilitate caregiver insertion, removal and hygiene.

Comparisons

It may be reasonably expected that a fixed prosthesis is preferred by patients because it is more stable than any removable appliance.¹⁴⁸ In a within-subject comparison of maxillary removable and fixed prostheses, five patients were provided with an implant supported maxillary removable overdenture and eight patients with an implant supported maxillary fixed prosthesis, all opposing a mandibular implant overdenture.¹⁴⁸ After two months each patient was fitted with the other type of prosthesis for a further two months.¹⁴⁸ The patients who wore the removable maxillary overdentures (with a long bar design and without palatal coverage) reported higher ratings of general satisfaction, ability to speak and ease of cleaning compared with the fixed prostheses.¹⁴⁸

Adaptation to new prostheses

The level of difficulty in adapting to a new prosthesis later in life is difficult to predict and measure.¹⁰

Treatment with dental implants must be considered in the context of a general trend of declining patient adaptive capacity with age that often results in problems.¹⁵

Some researchers have commented that patients who have been edentulous for several years and are therefore experienced denture wearers may be more likely not to be dissatisfied with their loose lower denture and less prepared to accept comprehensive treatment with implants.^{10,149} In a study of 48 patients greater than 80 years of age who had implants placed to support predominantly mandibular prostheses, 10% of patients experienced obvious problems with general adaptation and muscle control which had not been observed in younger patients.²²

Problems with the literature – success, survival, complications and maintenance

In order to accurately assess and report on implant success, it is necessary to measure appropriate clinical and radiographic parameters that may be benchmarked against standards. The most commonly accepted criteria for implant success was originally proposed by Albrektsson and colleagues,¹⁵⁰ and subsequently simplified by Zarb and Albrektsson.¹⁵¹ It required an implant to satisfy four criteria that focused on a healthy and harmonious relationship of the implant within the bone (Table 1).^{150–152}

More recently, new implant success parameters have been introduced such as health status of the peri-implant soft tissue (including plaque scores, gingival health index, presence of infection, bleeding), soft tissue contour, and patient-centred outcomes such as Pink Esthetic Scores.^{152,153} The variable methodologies employed to measure implant success are a significant problem in the literature and limit interstudy comparison, and often reduce the number of studies possible to include in systematic reviews.

In addition, the use of implant survival (the presence or absence of an implant irrespective of the status, or presence or absence of problems), prosthesis survival (the presence or absence of the prosthesis) and prosthesis success (the assessment of more subjective parameters such as precision of fit, aesthetics,

patient satisfaction and absence of complications¹⁵²) as measures of implant treatment introduce further complexities and variables in the reported literature.

During the lifespan of a prosthesis, maintenance (expected events) or complications (unexpected events) may occur that may or may not require intervention. The accuracy of the maintenance literature is problematic due to the uncertainty in what constitutes acceptable maintenance or repair; the reporting and varying definitions of maintenance; and the differences in classification of complications, adjustment and retreatment.^{95,154}

The variations in the methodologies used to assess implant treatment and the lack of consistency in categorization have at times resulted in very different outcomes from similarly focused research of similar treatments. Further complicating the ability of this review to provide definitive, scientifically based guidelines is the observation that much of the literature relating to the outcomes of single and multiple implant prostheses is not age specific. Therefore, it is only possible to provide a general perspective.

Social, economic and additional considerations

Social considerations in the context of dental treatment for the aged can be complex, poorly communicated and misunderstood. Issues may vary from quite subtle dissatisfaction with appearance or function to genuine reclusiveness that can mitigate the levels of desire and motivation for treatment.

The economic cost of any prosthodontic intervention is a balance between initial capital outlay (involving professional fees, laboratory fees and implant componentry costs), maintenance and repair costs, and any hidden costs of the service.^{154–157} While other less expensive treatment options exist, the benefits gained from dental implant treatment can be significant but at the same time difficult to measure. The economic cost of treatment is particularly important for the ageing population when income streams may be limited and/or fixed.

Additional elements of time, opportunity, discomfort and maintenance costs also play key roles both individually and collectively, and can be difficult to measure but at the same time often carry great significance for aged patients. When the costs exceed the perceived value, treatment may be questioned, alternatives considered or treatment declined. When the costs can be justified, treatment may proceed and patients are more likely to value their prostheses.¹⁵⁹

Clinicians tend to make negative stereotypical views of the ageing population on aspects such as life expectancy, manual dexterity and economic status.

Table 1. Criteria for implant success¹⁵¹

- | | |
|---|--|
| 1 | The resultant implant support does not preclude the placement of a planned functional and aesthetic prosthesis that is satisfactory to both patient and dentist. |
| 2 | There is no pain, discomfort, altered sensation, or infection attributable to the implants. |
| 3 | Individual unattached implants are immobile when tested clinically. |
| 4 | The mean vertical bone loss is less than 0.2 mm annually following the first year of function. |

Further, clinicians may at times be asked by aged patients, either directly or indirectly, to make judgements on the most suitable treatment option; a sometimes difficult and challenging task.

CONCLUSIONS

Aged patients do not appear to be associated with different implant success rates compared with younger patients.

The quality and quantity of bone available for implant placement are more important predictors of implant success than age. Local bone conditions are both age and site specific.

It is difficult to assess the isolated effect of ageing on implant treatment success due to the multifactorial nature of implant treatment, the diversity of variables that comprise implant treatment, confounding factors that affect treatment outcomes, variations in study designs and the issues faced in isolating age as a stand-alone element.

The scientific literature on implants in ageing populations is old and generally involves the treatment of edentulous patients.

Outside obvious absolute contraindications, most well-managed medical conditions commonly encountered in the ageing population do not pose a contraindication to treatment but may influence implant success and survival.

The replacement of single teeth with implant prostheses can be provided with the same success and relative risk in older populations compared with younger populations.

Different types of prostheses are associated with different levels of success, patient satisfaction and maintenance.

The mandible is very different to the maxilla as demonstrated by the different implant and prosthesis success and survival rates.

Maintenance requirements for most implant prostheses are significant, and in conjunction with the consideration of the patient's ability to maintain the prosthesis and their ease of access to future aftercare in later stages of life, is a crucial treatment consideration for aged patients. Short-term benefit must be balanced with long-term maintenance.

Different studies employ different methods of measurement for investigating the same variables which limits cumulative analysis and interstudy comparisons. The use of implant survival provides different results to the use of implant success which does not have universally standardized and accepted criteria. Therefore, readers are challenged to have a thorough knowledge of the subject matter before interpreting and applying the findings from individual studies, and at all times

should pay careful attention to the specific methodology used.

There are significant porosities in the literature that result in a lack of definitive clinical treatment guidelines, particularly for the restorative aspect of implant treatment, which requires clinicians to often manage cases on the basis of clinical experience, rational judgement and belief rather than an established evidence base.

Modern day implants have not yet been observed and reported in the literature for periods of 15 years or more. Much of the literature relating to the outcomes of single and multiple implant prostheses is not age specific.

DISCLOSURE

The author has no conflicts of interest to declare.

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