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MINI REVIEW

Is old age a risk factor for dental implants?

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Summary   Patient's condition is distinctly different among individuals especially in the elderly. Dental implant failure seems to be a multi-factorial problem; therefore, it is unclear that aging itself is a risk factor for the placement of implants. This review reorders and discusses age-related risk factors for the success of dental implants. In dental implant treatment, chronological age by itself is suggested as one of the risk factors for success, but it would not be a contraindication. In general, reserved capacity of bone and soft tissue make it possible to establish osseointegration in the long run. Rather than aging itself, the specific nature of the disease process, such as osteoporosis or diabetes, and local bone quality and quantity at the implant site, mostly related to aging, are more important for successful dental implant treatment. This review revealed a shortage of published data for the survival and success of dental implants in older patients. More studies useful for evidence-based decision making are needed to assess the survival and success of dental implants for aged patients with a compromised condition.
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1. Introduction

Previous researchers have reported prognostic risk factors for dental implants, including compromised general health (e.g., osteoporosis), smoking, implant location (e.g., maxilla, posterior), bone quality and quantity in the recipient site, implant length and immediate loading of the implant [1,2].

Patient's condition is distinctly different among individuals especially in the elderly. Implant failure seems to be a multi-factorial problem; therefore, it is unclear that aging itself is a risk factor for the placement of implants. This review reorders and discusses age-related risk factors for the success of dental implants.

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2. Chronological age

Age as a prognostic factor in implant success has been discussed by several authors. Older patients, theoretically, have potentially longer healing times, more systemic health factors, and the likelihood of poorer local bone conditions [3].

In an animal study on rats, aged 6 weeks (young group), 12 weeks (adult group), and approximately 2 years (old group), the young group showed that new trabecular bone formed actively around the implant, and good bone contact was achieved more rapidly than in the adult group. In contrast, in the old group both the quantity of newly formed trabecular bone around the implant and bone contact were less than in the other groups. The results suggest that the rate and volume of new bone formation around implants decrease with increasing age [4].

However, although some studies on implant treatment in the edentulous elderly suggested that age may be associated

Table 1 Studies reporting implant failure rate compared between in young and old patients.

Authors	Published year	Observed period (years)	Age group (years)	Sample size (persons)	Failure rate	Statistical significance	Remarks
Bryant and Zarb	1998	5—25 months	26—49	43	13.5	$P > 0.05$	Same clinic
			60—74	39	8		
Brocard et al.	2000	7	<40		17.5	$P < 0.02$	Multicenter
			40—60	440	11.4		
			60<		21.9		
Engfors et al.	2004	5	<79	115	Maxilla: 7.0, mandible: 0.5	$P > 0.05$	Edentulous patients
			≥80	133	Maxilla: 7.4, mandible: 0.3		Same clinic
Moy et al.	2005	Up to 20	<40	181	8.8	$P < 0.05$	Same surgeon
			40—59	418	13.3		
			60—79	499	17.9		
			79<	42	16.7		
Noguerol et al	2006	10	<40	117	4.3	$P < 0.05$	Same clinic
			41—50	347	6.3		
			51—60	357	7.0		
			60<	263	1.1		
Kinsel and Liss	2007	2—10	≤59	12	4.9	$P > 0.05$	Edentulous patients Immediate loading Same surgeon
			60<	31	4.4		

with a higher implant failure rate [5,6], the majority of previous studies indicated that increasing age alone is not a contraindication for implant treatment (Table 1) [7—14]. The findings that the use of implants in older patients was not contraindicated suggest that bone has a reserved capacity for osseointegration.

Moy et al. [6] studied a relatively large group of patients who had been operated on by an experienced surgeon and found that advanced age increased the risk of implant failure; patients older than 60 years were twice as likely to have adverse outcomes. Brocard et al. [5] analyzed cumulative success rates in a 7-year longitudinal study in a private practice setting with the same type of implant and found that in patients older than 60, only a relatively small number of implants remained.

In contrast, Meijer et al. [13] reported that Plaque Index, Gingival Index, Bleeding Index and bone loss after 3 years were not significantly different between younger and older patients. The authors concluded that the clinical performance of implant-supported overdentures in the mandible is equally successful in younger and older patients. Mesa et al. [14] reported that in a bivariate model, associations were found between primary stability failure and age, sex, smoking, oral and periodontal health status, maxillary or mandibular placement, placement of tooth site, bone quality, and implant diameter and length. However, in a multivariate logistic regression model, only females (odds ratio: 1.54), implants placed in the maxilla (odds ratio: 2.7) and implants shorter than 15 mm (odds ratio: 1.49) showed significantly higher risk of primary implant failure. These results suggested that age is a confounding factor associated with stability failure of implants. August et al. [15] showed that from a retrospective review of records at four clinical sites,

no age effect on implant success was shown between the older and younger male groups, nor was there a significant difference between premenopausal women and estrogen-supplemented postmenopausal women, although there was a significant difference between young and postmenopausal women. Therefore, the age variable appears to be less of a factor than does estrogen status.

3. Systemic factors

Dental implants and implant-supported prostheses are feasible treatment options for older patients; however, they present a number of problems not encountered in younger patients, including general health problems that might contraindicate surgery [1]. However, absolute medical contraindications to implant are rare. Implant surgery presents the same contraindications as any bone surgery, so it is very important to identify patients who have general pathoses, such as coronary diseases, anticoagulant treatment, diabetes, and osteoporosis [1].

However, patients with contraindications to implant surgery never make an impact on the success or failure rate in clinical statistics because patients with these general health problems never undergo an operation and would not be included in calculating the success rate.

3.1. Physiologic aging

The clinician must be aware of the physical, metabolic, and endocrine changes associated with aging and how these changes may affect implant treatment [11]. The human skeleton accumulates bone up to an age of approximately 30 years and then gradually starts to lose bone [16]. In

general, human bone mineral density (BMD) reaches a peak at age 25—30 years [17]. With increasing age, bones become weaker as a consequence of a reduced amount of bone tissue [18]. Age-associated bone loss is linked with an uncoupling of osteoblastic and osteoclastic activity in favor of osteoclasis [18]. Reduced estrogen bioavailability is the only independent predictor of bone mass in both men and women [19].

For women, menopause is associated with decreased estrogen levels, which in turn lead to increased bone resorption. The third National Health and Nutrition Examination Survey (NHANES III, 1988—1994) of the USA indicated that during the decade from 50 to 60 years, women lost about 10% of their hip BMD, compared to only 2% for men [20]. After age 70, men start to lose BMD at a similar rate to women. Two distinct syndromes of involutional osteoporosis were distinguished [21]: Type I or "postmenopausal" osteoporosis, in which a loss of trabecular bone is predominant, resulting mainly in fractures of the vertebrae and wrist, and Type II or "senile" osteoporosis, in which both cortical and cancellous bone are lost, resulting in hip fractures as well.

Clinical studies in humans showed a delayed course of bone healing with increasing age [22]. A reduced number of osteogenic stem cells, their reduced proliferation and differentiation potential, and reduced systemic or local blood flow have been discussed as reasons for this [23]. The time required for radiographic union following fracture increases with age in humans [24—26]. While young 6-week-old rats form bone to bridge the fracture gap by 4 weeks after fracture, adult 26-week-old rats require 10 weeks, and older 52-week-old rats need in excess of 26 weeks [27].

With respect to the effects of increased age on periodontal tissues, histological findings such as the following have been reported: thinning and diminished keratinization of the epithelium; decreased cell density and synthesized collagen in periodontal ligaments; and a decreased number of cells on the osteogenic layer of the alveolar bone [28]. There are "natural delays" in the healing of older individuals. Open wounds contract more slowly and incised wounds gain strength more slowly. Experimental studies indicate that cellular proliferation, wound metabolism, and collagen remodeling occur later in older animals. Clinical studies show, however, that operations can be performed safely in elderly patients and that the major increased risk to these patients is of non-wound medical complications that affect the wound [29]. The "normal" incisional wounds healed equally well in both groups. On the other hand, the ischemic wounds in the old animals were found to be impaired by 40—65% compared to similar wounds in the young animals [30]. Benatti et al. [28] showed that at 3 weeks, aging negatively influenced density of newly formed bone and percentage of bone fill in created fenestration defects of rats. At 6 weeks, aging also negatively influenced density of newly formed bone, but not percentage of bone fill. They concluded that aging may impair, but not prevent, periodontal healing.

All of those findings seem to indicate that aging affects the success of dental implants.

3.2. Pathologic aging

3.2.1. Diabetes
Diabetes mellitus is a significant disorder seen all around the world. The prevalence of diabetic patients increases with advancing age, especially in those over 50 and it was three times greater in females than in males, according to a USA study, The Third National Health and Nutrition Examination Survey, 1988—1994 [31].

Diabetic patients show delayed wound healing, frequency of microvascular disease, impaired response to infection, and susceptibility to periodontal disease [32], all potentially complicating factors when placing implants. Also, bone and mineral metabolism are altered in diabetics [33], possibly interfering with the integration process [3,32].

Fiorellini et al. [33] in a study of 40 patients found the survival rate of dental implants in controlled diabetic patients at approximately 85%. This was lower than that documented for the general population, but there was still a reasonable success rate. Morris et al. [34] found in a large sample population that Type 2 diabetic patients tended to have more failures than non-diabetic patients; however, the influence was marginally significant. In addition, Kapur et al. [35] compared diabetics who had only moderate levels of metabolic control with non-diabetic patients and also concluded that implants could be used successfully in diabetic patients.

Moy et al. [6] indicated that even patients with controlled diabetes were almost three times as likely to develop implant failure when compared to other patients. Interestingly, Olson et al. [32] found that the implant survival rate was relatively low in patients with Type 2 diabetes, and duration of diabetes had an effect on implant success. Greater failure rates were found in patients who had diabetes for longer time periods. The authors theorized that just as with the increased likelihood of other microvascular complications, an increasing duration of diabetes could cause microvascular disturbances that might contribute to implant complications. Therefore, older patients who have been diabetic for a longer time are likely to be affected by implant failure.

Klokkevold and Han [36] concluded in a systematic review that Type 2 diabetes may have a negative effect on implant survival, but the limited number of studies available for review makes this conclusion tentative. In addition, since the diabetic condition of patients in previous studies was under control, no comment can be made about implant survival in patients with uncontrolled diabetes.

3.2.2. Osteoporosis and estrogen status
Osteoporosis is the loss of bone mass and density throughout the body, including the jaws [37]. Decreased bone mass in postmenopausal women was reported to involve the alveolar ridges, similar to other bones in the body [38]. However, Boyde and Kingsmill [39] stated that common generalizations about the changes in bone due to aging and osteoporosis are too simplified, and that the mandible differs sufficiently from postcranial skeletal sites so that it would be unwise to extrapolate from findings in the jaw to circumstances elsewhere. It is not certain whether bone mass in the mandible and maxilla parallels bone mass in the rest of the skeleton, although it has been shown that mandibular bone mineral content decreases with age and that mandibular bone mass is lower in elderly female subjects than in male subjects [16].

Slagter et al. [40] found no association between systemic BMD status, mandibular BMD status, bone quality, and implant loss. Bone metabolism is impaired and thus, theoretically,

osseous integration may be more difficult to achieve in osteoporotic patients; however, established systemic osteoporosis does not imply that a jaw bone is unsuitable for osseous integration, nor is it an absolute contraindication to implant therapy [3]. Becker et al. [41] quantitatively measured osteoporotic bone loss in a group of dental implant patients and found that a simple visual assessment of bone quality at the site of implant placement may be more informative regarding implant failure than quantitatively measured osteoporotic bone loss. No correlation was found between the quantity of arm bone and implant failures [40]. Osteoporosis frequently occurs in postmenopausal women, but Dao et al. [9], in studying the association between premenopausal and postmenopausal women and implant failure, did not find a higher failure rate for implants placed in women older than 50 years as compared with women younger than 50 years or between women and men older than 50 years. Minsk and Polson [42] also found no correlation in older women with or without hormonal replacement therapy and implant failures.

None of the aforementioned studies differentiated between maxillary and mandibular implants. August et al. [15] examined jaw differences in pre- and postmenopausal women and found that the effect of postmenopausal estrogen status on compromised implant healing was shown in the maxilla but not in the mandible. The authors found that postmenopausal women not taking hormone replacements had the highest failure rate. Although a statistical difference was not achieved, estrogen replacement therapy reduced the maxillary failure rate by 41%. The authors reasoned that because osteoporosis affects trabecular bone more than cortical bone, and the maxilla has more trabecular bone composition than the mandible, the maxilla is therefore more susceptible to the effects of systemic osteoporosis.

It was reported that patients managed by surgeons who have done more of knee and hip replacement have lower risks of perioperative adverse events [43,44]. Moy et al. [6], in a retrospective cohort study on implants done by one very experienced oral and maxillofacial surgeon, evaluated systemic osteoporosis and its effect on implant failure. The authors showed that patients who were postmenopausal and hormone replacement therapy experienced significantly increased implant failure. The authors showed that postmenopausal patients who were taking hormone replacement therapy experienced significantly increased implant failure.

4. Quality and quantity of available bone

Bone quality is related to osseointegration, and bone quantity is related to the length of the implant, which is important for initial stability and longitudinal success [45,46]. As stated previously, both quality and quantity are theoretically affected by aging.

Subsequent histomorphometric and microradiographic studies showed that after the age of 50 there was a marked increase in the cortical porosity of the mandible, with this increase being greater in the alveolar bone than the mandibular body. With this increase in porosity, there was a concomitant decrease in bone mass, which appeared to be more pronounced in females than in males, with the loss in bone mineral content estimated to be 1.5% per year in females and 0.9% in males. These studies also demonstrated a considerable amount of variation in the amounts of cortical and trabecular bone within and among individuals [47].

Significant or strongly significant differences were found regarding implant failures as a result of jaw bone quality, jaw shape, implant length, treatment protocol, and combinations of jaw bone-related characteristics [45]. Approximately 65% of the patients with a combination of the two most negative bone-related factors (jaw bone quality 4 and jaw shape D or E) experienced implant failure. Implant length, the only implant-related factor evaluated, was also significantly correlated with the success rate, but implant length could also be regarded as a result of the jaw bone volume available. In most cases this was also indirectly or partly related to the status of the jaw bone available for implant placement [45].

Morphologically, bone resorption of the labial or buccal ridge makes prosthetic treatment much more difficult. Horizontal discrepancies between the residual ridge of one jaw for implantation and the residual teeth or ridge of the other jaw are common. It is not an age-specific phenomenon, but occurs frequently in the elderly. Bone quality is of concern for implant success. To improve our understanding of how the site-specificity of jaw bone condition affects oral implant outcomes, research needs to be aimed at establishing reliable and valid measures of preoperative jaw bone condition, and at better documenting the effects of jaw bone condition on oral implant outcomes [48]. Objective evaluation of bone quality and quantity with a CT (3-dimensional shape and bone mineral density of local bone), which has not been established will be important for successful dental treatment [45].

5. Adaptation and maintenance

As with other prosthetic treatments, adaptation to the prosthesis and the ability to maintain it, including having access to a dental office, are important with dental implant patients. More problems with adaptation in the elderly patients could be observed. Elderly patients especially had more postinsertion problems than those in younger age groups. Jemt [49] followed 48 patients more than 80 years old (mean age 82.7 years) who had received a total of 254 implants and found that most had minimal postplacement problems, similar to what has been observed in younger patients. However, some patients (10%) experienced obvious problems with general adaptation and muscle control, which has not been observed in younger patients. Oral hygiene problems and associated soft tissue inflammation (mucositis) as well as tongue, lip, and cheek biting were observed significantly more often among the elderly patients [7].

6. Problems and limitations in clinical studies

Study design remains important. Retrospective cohort studies are easier to complete but due to problems of selection bias and confounding have less validity than randomized prospective clinical trials. The conclusions that can be drawn from retrospective studies may be limited [50]. In such studies, successful patients and treatment plans tend to be influenced by ethical considerations so that success rates

must be relatively high, whether subjects are young or old, healthy or compromised. We have to realize that if study samples include all applicants for implant treatment, the success rate for older patients must be lower than that for younger ones. Interestingly, Noguerol et al. [46] showed that in the multiple logistic model, younger age (odds ratio: 4.53), as well as smoking habits (OR: 2.59), and bone quality (OR: 1.93) were independently related to early failure. This effect is odd and may be caused by a selection bias, where those over the age of 60 would only be treated with implants under 'ideal' conditions or might, as past users of removable prostheses, value and take greater care of their new fixed prostheses.

Clinicians need the results of randomized, controlled clinical trials for evidence-based decision making. However, these types of studies are difficult to design and are time-consuming, expensive and possibly unethical [3].

7. Conclusion

In dental implant treatment, chronological age by itself is suggested as one of the risk factors for success, but it would not be a contraindication. In general, reserved capacity of bone and soft tissue make it possible to establish osseointegration in the long run. Rather than aging itself, the specific nature of the disease process, such as osteoporosis or diabetes, and local bone quality and quantity at the implant site, mostly related to aging, are more important for successful dental implant treatment.

This review revealed a shortage of published data for the survival and success of dental implants in older patients. More studies useful for evidence-based decision making are needed to assess the survival and success of dental implants for aged patients with a compromised condition. Long-term studies are expected to be more revealing of the influence of risk factors related to aging.

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