Effect of Age on Single Implant Submersion Rate in the Central Maxillary Incisor Region: A Long-Term Retrospective Study

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ABSTRACT

Background: It is contraindicated to place dental implants before growth and development are completed as they are at a risk of submersion due to growth arrest, creating a potential aesthetic problem.

Purpose: The present study evaluated the effect of age on mean submersion rate of single dental implant in the central maxillary incisor area as compared with the adjacent natural tooth in implants placed after growth has ceased.

Materials and Methods: A retrospective study was conducted on 35 patients (mean age 29.3 ± 9.9 years, 21 females) who received a single dental implant replacing a missing maxillary central incisor from 1992 to 2008 with a follow-up of at least 3 years. Clinical photos from last follow-up were digitally analyzed to measure the vertical change between the incisal edge of the implant supported crown and the adjacent natural central incisor.

Results: In the younger age group (≤30 years), the submersion rate was more than three times higher than in the older age group (>30 years), yielding submersion rates of 1.02 and 0.27% per year, respectively.

Conclusions: Whereas implant submersion continues throughout adult life, its rate varies with age. It is evident that this phenomenon is much more conspicuous during the second and third decades of life as compared with the fourth and fifth.

KEY WORDS: age, dental implants, long term, submersion rate

INTRODUCTION

The use of single dental implant replacing missing teeth at the upper anterior region has many advantages as compared with conventional prosthetic treatment. However, there is ample evidence that osseointegrated implants, much like ankylosed teeth, do not erupt or displace together with adjacent teeth during growth of the jaws.[1–3] Therefore, are at a risk of creating an aesthetic problem due to infraocclusion with time.[4]

It is contraindicated to place dental implants before growth and development are completed. This can be verified by examining joint maturation on the basis of a wrist x-ray.[3,5] Yet, craniofacial dimensions demonstrate changes also during adulthood[6–8] including teeth eruption and vertical development of their surrounding tissues[9,10]; these situations may occur also later in life.[11]

The aim of the present study was to evaluate the effect of age on the mean submersion rate of single dental implant, replacing a central maxillary incisor, placed after growth has ceased, as compared with the adjacent incisor natural tooth.

PATIENTS AND METHODS

Study Population

A retrospective study was conducted on patients' files who received a single dental implant replacing a missing anterior maxillary tooth from 1992 to 2008. Ninety nine consecutive patients files were surveyed, and the final

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study population comprised of 35 patients (mean age at implant placement 29.2 ± 10.9 years, 14 females) who met with the inclusion criteria of receiving a single dental implant to replace a missing maxillary central incisor in between natural teeth, with a clinical and radiographic follow-up of at least 3 years. The majority of implants (25) were placed by one surgeon (DSA) rehabilitation performed by several practitioners, whereas 10 implants placement were performed by various surgeons rehabilitated by single prosthodontist (NB). The mean follow-up time was 7.5 ± 4.5 years. Patients were divided to two groups according to the age at time of implant placement: ≤30 and >30 years old. Gender, soft tissue complications, augmentation procedures (soft and/or hard tissue), and cervical bone loss were also examined and compared with the mean submersion rate.

Submersion Rate Measurement

In the present study, clinical photos from last follow-up were used to measure the change in vertical dimension between the incisal edge of the implant supported crown of the missing central incisor and the adjacent natural central incisor,[12] considering that the restoration was performed at the same incisal level of the neighboring natural central incisor, as shown in Figure 1.

The clinical images were digitally analyzed (Image J software; National Institutes of Health, Bethesda, MD, USA) and due to the lack of uniformity and scale in the photos, the mean submersion rate was defined in terms of percent of crown occlusal-gingival length per year:

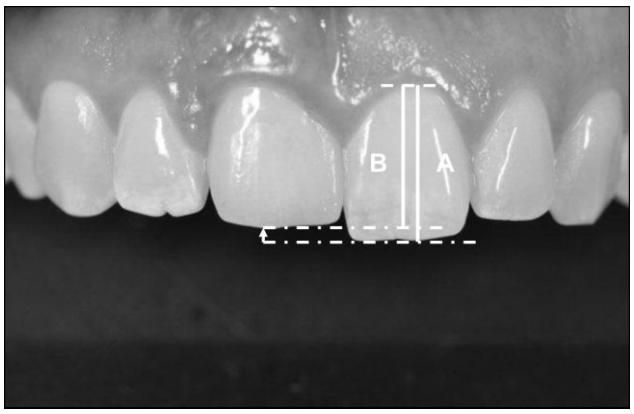

Figure 1 This figure shows a typical clinical photo of a submerged implant supported restoration (#11). Submersion rate was measured according to the adjacent natural tooth (A and B) divided by follow-up time.

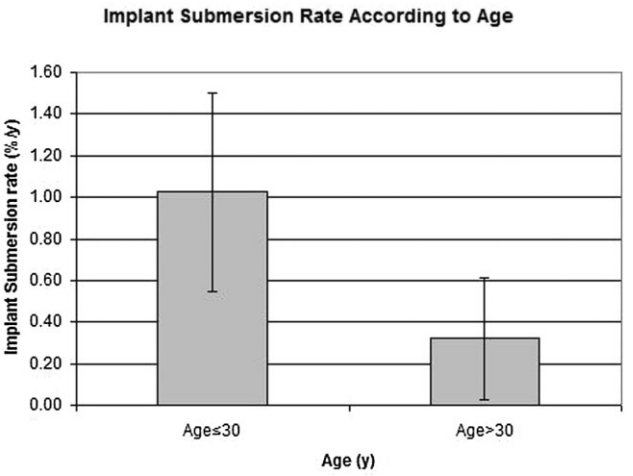

Figure 2 This figure shows the mean result (±SD) of the mean implant submersion rate for the various age groups (<20, 20–30, 30–40, 40–50). The difference between under and over 30 years old were statistically significant ($p < .001$).

$$\text{Mean Submersion Rate} = \frac{\left[\frac{A-B}{A}\right]\cdot 100}{\text{Years of follow-up}}$$

Statistical Analysis

To compare the mean submersion rate and related parameters between the two age groups (i.e., ≤30, >30 years old), *t*-test was applied.

The Spearman correlation coefficient and regression analysis were calculated to estimate the association between age and mean submersion rate. All the tests applied were two tailed, and $p \leq 0.05$ was considered statistically significant.

RESULTS

The mean submersion rate of the implant supported restoration in the younger age group (≤30 years) was more than three times that of the older age group (1.02 and 0.27%, respectively; Table 1). Accordingly, significantly higher proportion of soft tissue complications was also observed in the younger age group as compared with the older one. No statistical differences were seen between these two age groups for the other parameters (e.g., gender ratio, follow-up time, and additional procedures).

The mean submersion rates occurring in the different decades of life are presented in Figure 2. Whereas,

TABLE 1 Mean Submersion Rate and Related Parameters according to Age

Parameter	Age Group (Mean Value ± SD) ≤30 Years Old	>30 Years Old	*p* Value
Patients	22	13	–
Females	15 (68%)	7 (54%)	0.329
Age	22.7 ± 4.3	40.4 ± 5.6	<0.001*
Follow up (y)	7.2 ± 3.6	7.1 ± 4.8	0.938
Mean submersion rate (%/y)	1.02 ± 0.46	0.27 ± 0.24	<0.001*
Immediate/delayed	9/13	5/8	0.806
Bone augmentation	16 (73%)	11 (85%)	0.408
Gingival graft	5 (23%)	4 (30%)	0.464
Soft tissue complications	9 (40%)	2 (18%)	0.042*
Bone loss	2 (9%)	1 (8%)	0.548

*$p < .05$ considered statistically significant difference.

no statistical differences were observed between the second and third decades or between the fourth and fifth, a clear significant difference ($p < .001$) was seen between patients over and under the age of 30.

Results of the regression analysis between the mean submersion rate and age are shown in Figure 3. These results clearly show an inverted association between submersion rate and age, yielding a regression coefficient of −0.03 ($R^2 = 0.38$) as well as a negative correlation coefficient of $r = -0.65$ (Spearman) with a p value of under .001.

The comparison of mean implant submersion rate between males and females is described in Figure 4. Although these results show a clear tendency for higher submersion rate in females as compared with males, these results were not statistically significant ($p = .087$).

DISCUSSION

Single-tooth implants are commonly used to replace missing teeth. However, like ankylosed teeth, osseointegrated dental implants alter position as growth-related changes occur within the bones of the jaws (displacement, remodeling, and mesial drift), hence, if implants are placed before cessation of facial

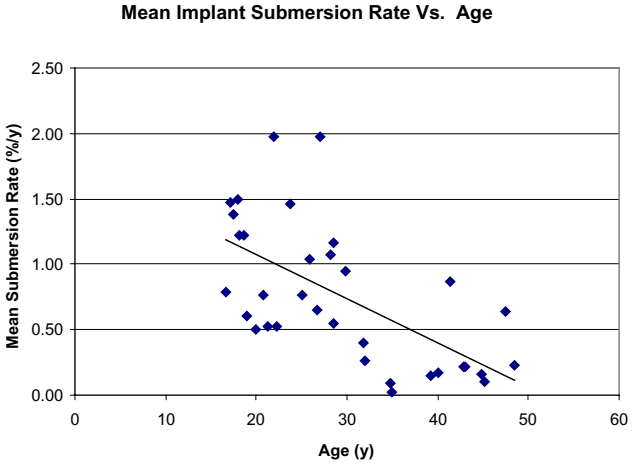

Figure 3 This figure shows the linear regression analysis of the implant-supported restoration mean submersion rate (% per year) according to the patient's age at time of implantation.

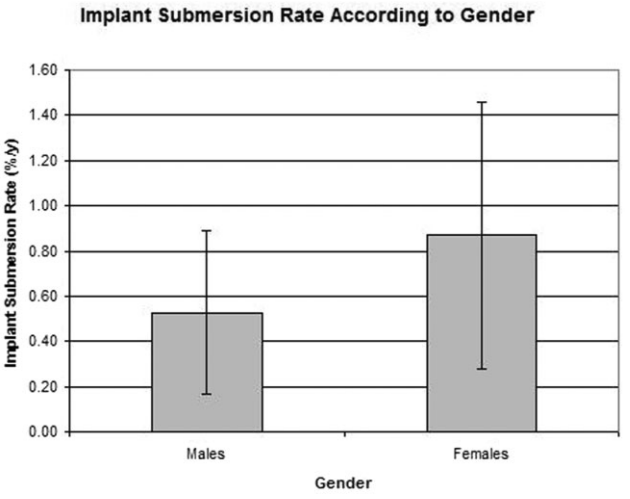

Figure 4 This figure shows the mean result (±SD) of the mean implant submersion rate for males and females. The difference between the two groups was not statistically significant ($p = .087$).

growth, they will submerge relative to the adjacent erupting teeth. Facial growth of the child or adolescent, as well as the continuous eruption of the adjacent anterior teeth, creates significant risk of a less favorable esthetic and/or functional outcome. It is a common knowledge that the growth of the facial skeleton continues after puberty, but the amount of growth decreases steadily and after the second decade of life seems to be clinically insignificant.[13] Yet, in a research published in 2006,[13] the authors findings indicated that the growth of the facial skeleton continues after puberty; there is a difference in the amount of growth between the sexes during the second decade of life, and after age 20, the intergender difference is substantially diminished; and the rate of eruption of the maxillary central incisors in females seems to be greater than in males. It was also documented that for patients with a short or long face type, further growth, especially the continuous eruption of adjacent teeth, creates a serious risk even after the age of 20.[14]

The results of the present research suggest that whereas implant submersion continues throughout adult life its mean rate varies with age. It is evident that this phenomenon is much more conspicuous during the second and third decades of life as compared with the fourth and fifth. Although there are numerous publications on long-term follow-up of single implant replacing anterior maxillary incisors, there are only few studies referring to the phenomenon of continuous maxillary growth after puberty and its effect on the incisal implant restoration level compare with the neighboring natural tooth, nor the changes in the free gingival level.[12,15]

Jemt[16] studied the long-term clinical and radiographic data on single-implant treatment in the anterior maxilla and compared these results with comparable data of central implants supporting fixed prostheses in the edentulous maxilla. It was demonstrated that early single-implant restorations showed significantly more mechanical/fistula problems compared with central implants in the edentulous maxilla ($p < .05$), but bone response was similar for both groups during 15 years of follow-up. Bone loss was not affected by the level of the implant head in relation to the cementoenamel junction of adjacent teeth, nor was it affected by mechanical or mucosal problems or persistent fistulas of the single implants during the entire follow-up period. These results are in agreement with the present study that did not find any statistical relations between mean implant submersion and bone loss but did find a significant higher tendency for soft tissue complication in patient under 30 years old in which mean submersion rate was higher (see Table 1). Previously, we have examined the long-term aesthetic and clinical success of a single dental implant in the anterior maxilla. We assessed marginal bone loss, survival and success rates as well as the average examiners' satisfaction from the aesthetic outcome. We have concluded that implantation in the anterior maxilla has high surgical survival and success rates, as well as a considerably high aesthetic success rate. However, these high surgical success and survival rates could not predict the aesthetic success. Interestingly, despite the long follow-up presented in these studies, we failed to notice and describe the submersion phenomenon.[17,18]

Jemt and colleagues[19] analyzed the prevalence and magnitude of tooth movements adjacent to single-implant crowns in a long-term study and discussed these changes in relation to changes in cephalometric measurements of a reference group after 10 years. These authors observed higher incidence of tooth movements adjacent to implants in females and attributed this to significantly greater increase of anterior face height and posterior rotation of the mandible as compared with males. The present results provides further support to this observations, by demonstrating a trend (although not statistically significant) of greater adjacent tooth movements in females.

Although other factors may contribute to tooth movements (e.g., passive eruption and malocclusion), the present findings indicates that age is the most significant factor affecting mean implant submersion rate. These findings are in disagreement with previous study of Bernard.[11] Although an eruption of adjacent teeth was recorded in all the patients, no difference in vertical changes of anterior maxillary teeth adjacent to a single implant between young and mature adults as and between males and females was recorded. Although the studies employed different methodologies (i.e., measuring techniques, inclusion criteria, and reference to rate of submersion), these differences warrant further investigation.

A previous study showed that the implant submersion may also cause a reduction of bone height in the adjacent tooth especially mesially to the implant.[4] However, the radiographs in the present study demonstrated

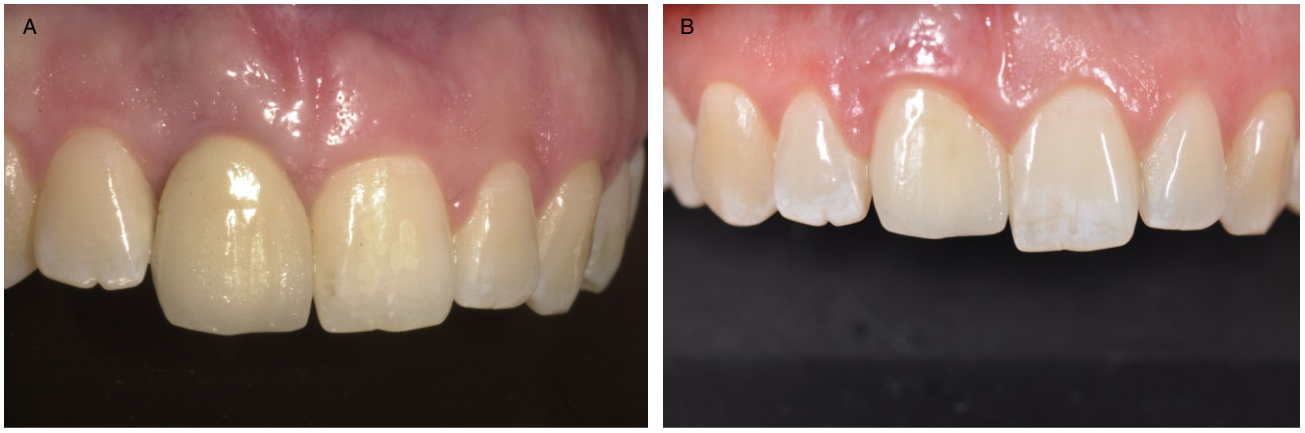

Figure 5 Typical clinical photo illustrating the submersion process showing the implant supported restoration's position following restoration ("before" on the left [A]) and at six years follow-up ("after" on the right [B]).

that the adjacent teeth had erupted together with the crestal bone leaving a deep scalloped crater formation around the implant (data not shown).

Though some patients present with an aesthetic complaint of a "short tooth" due to the gradual and slow nature of implant submersion, it sometimes goes unnoticed. Interestingly, it is finally noticed during the routine annually or biannually follow-up visits when inflammation and discoloration of the soft tissue appears above the implant supported restoration at the free gingival margin (Figure 5, "after"). This inflammation is most likely the result of an increase in the transmucosal depth of the implant-abutment interface brought about by the implant submersion, which was previously shown to effect and shifts the bacterial population of the implant's inner compartment toward a more anaerobic periopathogenic oral bacteria,[20] and toxins release into the peri-implant pocket. In some cases, this condition will be propagated due to the submersion of the implant-supported restoration's height of contour into the free gingival line. In some cases, a free gingival graft was attempted to correct this problem (see Table 1). However, in some cases, this was not sufficient, and crown replacement was warranted. Furthermore, the aesthetically impaired appearance brought about by the submerged restoration can also be mended by its replacement over the years.

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