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A distinguishable observation between survival and success rate outcome of hydroxyapatite-coated implants in 5–10 years in function

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Date:
Accepted 15 February 2005

To cite this article:
Artzi Z, Carmeli G, Kozlovsky, A. A distinguishable observation between survival and success rate outcome of hydroxyapatite-coated implants in 5–10 years in function.
Clin. Oral Impl. Res.
doi: 10.1111/j.1600-0501.2005.01178.x

Key words: HA-coated implant, hydroxyapatite, retrospective study, success rate, survival rate

Abstract

Purpose: To differentiate between the survival and success definitions of functional hydroxyapatite (HA)-coated implant prosthesis.

Methods: A total of 248 implants (62 patients), 5–10 years in function, were evaluated. The implant distribution length was 8 mm (6.5%), 10 mm (29.4%), 13 mm (30.2%) and 15 mm (33.9%). The diameter was 3.25 mm (60.1%) and 4 mm (39.9%). Probing depth (PD), gingival index (GI), height of keratinized mucosa (KM) and recession (REC) were measured. Periapical radiographs were taken to estimate the amount of crestal bone resorption (BL), mesially and distally, with the aid of a millimetric-scaled magnifying glass (× 8). Only implants that fulfilled the success rate criteria were considered as successful. All other functional implants were assigned to the non-successful group. All functional implant prostheses were defined as survival ones.

Results: The accumulative survival rate after 5 and 10 years was 94.4% and 92.8%, respectively. Accumulative success rates were 89.9% and 54%, respectively. Implants 13 and 15 mm in length (97.9% and 96.4%, respectively) had the highest survival rate, which was higher over implants 8 and 10 mm in length (75%, $P<0.01$ and 88.2%, respectively). The survival rate of 4 mm diameter implants compared with 3.25 mm was 96.5% and 90.3%, respectively ($P=0.019$). The average BL was 1.7, 0.92 and 2.79 mm for the survival, successful and non-successful defined implant groups. PD was 3.26, 2.79 and 4 mm and GI was 0.96, 0.75 and 1.57, respectively. These measurements were statistically different between implant groups. KM and REC measurements showed similar scoring for all groups. A correlation was shown between successful and non-successful implants on the score of GI and PD ($P<0.001$ in both).

Conclusion: A distinguishable observation between survival and success rate was noted particularly in long-term observations. Implant length and diameter have an influence on the survival rate. Clinical parameter scores expressed an influence on the defined implant status.

Titanium implant surface alterations have been shown to enhance osseointegration. These alterations should maximize bone healing and direct contact for predictable long-lasting function. Hydroxyapatite (HA)-coated implants, introduced by the mid-1980s (de Groot et al. 1987; Geesink et al. 1988), were innovative since they allegedly produced chemical bonding between its surface and the osseous tissue. HA coating shows certain benefits (Albrektsson & Sennerby 1991; Wheeler

1996; Wie et al. 1998; Iamoni et al. 1999; Orenstein et al. 2000), but its long-term success and predictability have been questioned (Watson et al. 1998; Lauc et al. 2000; Simunek et al. 2002).

The HA-coated implant system was extensively evaluated in the 2000 VA study (Morris 2000), a 3-year multicenter prospective study, which reported the characteristics of this type of implant to be favorable. HA-coated implants have been shown to be an advantageous system (Block & Kent 1994; Hahn & Vassos 1997; Morris & Ochi 1998; Jones et al. 1999; Lee et al. 2000; Geurs et al. 2002; Jeffcoat et al. 2003; McGlumphy et al. 2003). In certain types of HA, calcium phosphate ceramic coating may improve the biocompatibility profile, which accelerates bonding to bone and enhances mechanical force transfer (Lemons 1988; Lemons & Dietsh-Misch 1999). The HA-coated implant is actually a fired ceramic $Ca_{10}[PO_4]_6[OH]_2$ that forms a high-density and pure crystalline monolytic HA (Lemons & Dietsh-Misch 1999).

Histologic observations (Block et al. 1989; Kakutani et al. 1989; Hayashi et al. 1991) have shown an increase in bone penetration toward the HA surface in which fixation is enhanced. The osseous remodeled tissue, in proximity to the HA, shows a high degree of mineralization and organized lamellar arrangement (Thomas et al. 1987). On the cellular level, an increase in osteoblast-like cell activity on the HA surface and the crystallite size of HA surfaces could play an important role in governing cellular response (Ong et al. 1998). Nevertheless, although HA-coated implants have been suggested as being bioactive, a considerable difference has been shown between different types of HA coating (Jarcho 1992) at the level of crystallinity (Mohammadi et al. 2004) and difference of HA granule coating (Kakutani et al. 1989).

Furthermore, there are several controversial findings regarding HA coating. The relatively low shear and fatigue strengths of its calcium phosphate-based ceramics (Lemons 1988), as well as its delayed solubility (Lemons & Dietsh-Misch 1999) and resorption (Buser et al. 1991a) during function, can be anticipated. There is also a reduction in coating thickness after *in vivo* function (Caulier et al. 1997), and vulnerable interface attachment between the HA coating and the implant metal body (Cook et al. 1987; de Groot et al. 1987; Thomas et al. 1987). Under scanning electron microscopy, Ogiso et al. (1998) examined HA-coated implants in coxal bone of dogs during a 10-month period. They found that the crystallization of the coating was weakened and an amorphous brittle phase developed, causing stress accumulation within the coating and subsequently, a decrease in binding strength. It was concluded that HA coating eventually dissolved in soft tissue. Such an observation was also reported in humans (Overgaard et al. 1997), and later confirmed in a postmortem histologic evaluation (Rohrer et al. 1999).

In a thorough critical review, Albrektsson (1998), challenged most clinical reports on HA-coated implants to be an unsupportive documentation with lack of choice of a definite criteria of success.

Therefore, the credibility of any implant design should be examined under definite criteria. Several criteria regarding implant success rate have been suggested (Schnitman & Shulman 1979; Albrektsson et al. 1986; d'Hoedt & Schulte 1989; Smith & Zarb 1989; Buser et al. 1991b), with the most stringent one often being used (Albrektsson et al. 1986). These criteria proposed that the crestal bone loss (BL) should not exceed 1 mm in the first year of function and 0.2 mm on each subsequent annual year. Weber et al. (2000) have shown that in a rough implant surface (sandblasted large grit acid etched), the mean crestal BL in the first year was only 0.6 mm followed by an annual yearly loss of approximately 0.05 mm. Nevertheless, Becker et al. (2000) by evaluating titanic plasma-sprayed and machine-threaded (the traditional Brånemark type) surface fixtures, revealed insignificant crestal bone resorption after 2–3 years follow-up, which fulfilled the success criteria definition. Similar findings were obtained in a recent study (Astrand et al. 2004).

Another term used for long-term efficacy of functional implants is survival rate, sometimes referred to as an asymptomatic implant in function (Kirsch & Ackermann 1989; Albrektsson & Sennerby 1991). Albrektsson (1998) stated that survival and success terms should be distinguished in each clinical report. The different success/survival criteria on osseointegrated implants have been evaluated and summarized (van Steenberghe 1997; van Steenberghe et al. 1999): total biocompatibility, steady anchorage to the functional prosthetic superstructures, present with no technical and/or mechanical hazards, no radiographic radiolucency and total immobilization. The ongoing marginal BL should be observed by clinical and radiographic means during follow-up.

Since different success/survival rate criteria (Kent et al. 1990; Albrektsson & Sennerby 1991; Lozada et al. 1993; Block & Kent 1994; Block et al. 1996; Wheeler 1996; Watson et al. 1998; Cochran 1999; Lee et al. 2000; Truhlar et al. 2000; Tinsley et al. 2001; Simunek et al. 2002; Jeffcoat et al. 2003; McGlumphy et al. 2003) present different data on the long-term function of HA-coated implants, it was decided to evaluate and distinguish between survival and success terms in cumulative measurements. The success criteria used were adopted from Smith & Zarb's (1989) and Albrektsson & Sennerby (1991), and modification of Albrektsson et al. (1986) and van Steenberghe (1997) definitions.

The aim of this retrospective study was to evaluate the success/survival rates of cylindrical HA-coated implants (Integral®, Calcitek, Carlsbad, CA, USA) after 5–10 years in function by clinical and radiographic diagnostic tools. These parameters would clearly distinguish between survival and success definitions of the functional implant prosthesis.

Material and methods

HA-coated implants (Integral® and Integral Ommilock®, Calcitek) were placed surgically according to the two-stage Brånemark protocol in non-augmented/regenerated edentulous ridge sites. Originally, 66 patients, in good general health and not considered as heavy smokers (less than 15 cigarettes a day), were treated. A total of 255 implants were placed. There were four dropout patients who had seven implants. No data were obtained regarding their status, and were eventually not considered in the final analysis. Consequently, 62 patients (42 females and 20 males) were admitted to the study. Their age ranged from 26 to 80 years (average 56.5 years).

Implants ($n = 248$) were 5–10 years in function. Two clinicians (Z.A., A.K.) treated all patients. The procedure was explained to the patients, and all signed an informed consent. The Ethics Committee of Tel Aviv University approved the study.

The prosthetic phase was performed 4–6 months after the surgical procedure. All data obtained from the patients' records were summarized on a special form. Patients' physical status was classified according to the American Society of Anesthesiologists (Keats 1978) in rank ASA 1–4: Class 1, healthy patient; Class 2, mild systemic disease; Class 3, severe systemic disease but not incapacitating; and Class 4, severe systemic disease that is a constant threat to life. Only patients who ranked ASA-1 or -2 were considered: 54 patients (87.1%) with no systemic disorders were classified as ASA-1; 8 patients (12.9%) with disorders such as blood hypertension, hyperlipidemia, and hyperthyroidism were classified as ASA-2. Patients were divided into smokers ($n = 7$; 11.3%) and non-smokers ($n = 55$; 88.7%) and were periodically recalled between one and three times annually. The implant distribution length was 8 mm ($n = 16$, 6.5%), 10 mm ($n = 73$, 29.4%), 13 mm ($n = 75$, 30.2%), and 15 mm ($n = 84$, 33.9%). The implant diameter was 3.25 mm ($n = 149$; 60.1%) and 4 mm ($n = 99$; 59.9%). There were 41 (66.1%) partially and 21 (33.9%) completely edentulous patients. Implants were placed in the anterior ($n = 77$, 31.1%) or posterior mandible ($n = 66$, 26.6%) and anterior ($n = 63$, 25.4%) or posterior maxilla ($n = 42$, 16.9%). The nature of the prosthesis, i.e., fixed or removable, cemented or screwed, etc., as well as the nature of the opponent natural/prosthetic dentition was recorded.

Periodontal parameters used during the clinical examination were probing depth (PD) at four sites (distolingual – DL, mesiolingual – ML, distobuccal – DB, mesiobuccal – MB) using a color-coded probe, gingival index (GI) (Silness & Löe 1964), width of keratinized mucosa (KM) (lingually and buccally in the mandible, buccally in the maxilla) and height of recession (REC) (distance of prosthetic margin to free mucosal margin). An orthoradial periapical radiograph was taken and compared with the radiograph taken at the initial time of loading. For each implant, crestal bone resorption was measured mesially (M) and distally (D) from the coronal aspect of the implant to the current bone level in contact (radiographically) with the implant surface. The average of M and D was calculated as the crestal bone resorption of each implant. The distance between the implant to the adjacent tooth/implant was also recorded. These radiographic measurements were taken with the aid of a magnifying glass ($\times$ 8 magnification), where a millimetric scale (0.1 mm) was taped on the lens. To determine the reproducibility of the measurement and the coefficient of variation for each radiographic distance, 10 randomly selected periapical radiographs were measured five times, without reference to the previous data. The mean coefficients of variation of mesial and distal crestal bone resorption and inter implant/tooth distance were 2%, 1.8% and 1.6%, respectively, indicating that these measurements were highly reproducible. Only fixtures that fulfilled the success rate criteria (Albrektsson et al. 1986; Smith & Zarb 1989), i.e., up to 1.8 mm crestal bone resorption after 5 years and up to 2.8 m after 10 years, were considered as successful implants. All other functional implants were considered as survival ones. Implants that established osseointegration but were later removed were considered as failures.

The Kaplan–Meier estimation method was used to calculate the accumulative survival and success rate. Log rank test was used for assessing the statistical significance. The association between survival and success rate and each patient/implant variable was analyzed using χ^2 test. The difference between the mean value of clinical parameters and survival/success group was evaluated by a non-paired *t*-test. Unless noted, the Pearson correlation was significant at the 0.01 level (2-tailed).

Results

After 10 years, the Kaplan–Meier Estimator accumulative survival rate was 94.4% ($\pm$ 1.5) after 5 years and 92.8% ($\pm$ 1.8) after 10 years in function. When these implants were calculated according to the success criteria of Albrektsson et al. (1986), the cumulative success rate was 89.9% ($\pm$ 1.9) after 5 years, decreasing to 54% ($\pm$ 5.7) after 10 years (Fig. 1, Table 1). Cross tabulation between survival and success rates showed that in success terms at 10 years, 56 implants (24.8%) that survived were considered failures.

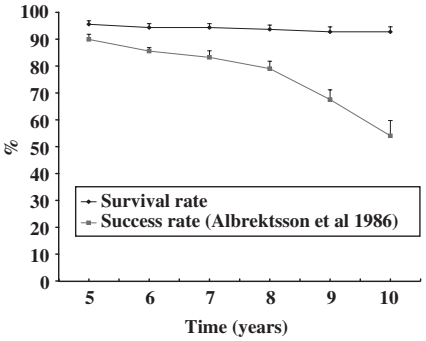

Fig. 1. Survival/success rates in 5–10 years in function.

***Table 1*. Cumulative survival and success rates in time**

Time (years)	Survival rate (%)	Success rate (%)
5	94.4 $\pm$ 1.5*	89.9 $\pm$ 1.9
8	93.7 $\pm$ 1.6	79.1 $\pm$ 2.8
10	92.8 $\pm$ 1.8	54 $\pm$ 5.7

*Standard error.

Upper and lower arch distribution revealed that 4.9% of the mandibular implants ($n = 43$) and 14.3% of the maxillary ones ($n = 105$) did not survive, with a borderline Log rank statistical significant difference ($P = 0.056$) between them. In accordance with the success criteria, 21.7% of the mandible and 44.8% of the maxilla were unsuccessful ($P = 0.009$). Different areas in the upper and lower jaws showed that the anterior and posterior regions of the mandible showed the highest survival rate (96.1% and 96.9%, respectively), followed by the anterior and posterior regions of the maxilla (88.4% and 86.9%, respectively) (Table 2). The success rate criteria at the anterior and posterior mandible were 38.4% and 78.6%, respectively, and, 37.6% and 54.4%, respectively, at the anterior and posterior maxilla. A log rank statistical significant difference was shown between the posterior mandible to the anterior maxilla ($P = 0.01$) and to the posterior maxilla ($P = 0.038$) (Table 3).

While gender did not play a role in survival and success rates, there was a relative weak correlation between survival

Table 2. **Cumulative survival rates according to implant location**

Time (years)	Mandible		Maxillary	
	Anterior	Posterior	Anterior	Posterior
	($n=77$)	($n=66$)	($n=63$)	($n=42$)
5	96.1 ± 2.2	96.9 ± 2.1	92.1 ± 3.4	90.5 ± 4.5
8	No change	No change	No change	86.9 ± 5.6
10	No change	No change	86.4 ± 4.8	No change

Table 3. **Cumulative success rates according to implant location**

Time (years)	Mandible		Maxillary	
	Anterior	Posterior	Anterior	Posterior
	($n=77$)	($n=66$)	($n=63$)	($n=42$)
5	92.2 ± 3.1	92.4 ± 3.2	88.9 ± 3.9	83.3 ± 5.7
8	83.3 ± 4.5	87.3 ± 4.2	73.7 ± 6.3	66.4 ± 7.7
10	38.4 ± 6	78.6*† ± 6.1	37.6* ± 9.8	54.4† ± 9.3

*$P=0.01$.
†$P=0.038$.

Table 4. **Cumulative survival rates according to implant length**

Time (years)	Implant length (mm)			
	8 ($n=16$)	10 ($n=73$)	13 ($n=75$)	15 ($n=84$)
5	87.5 ± 8.3	90.4 ± 3.4	100	97.6 ± 1.6
8	75*† ± 10.8	No change	97.9* ± 2.1	96.4† ± 2
10	No change	88.2 ± 4	No change	No change

*$P<0.001$.
†$P<0.0018$.

Table 5. **Cumulative success rates according to implant length**

Time (years)	Implant length (mm)			
	8 ($n=16$)	10 ($n=73$)	13 ($n=75$)	15 ($n=84$)
5	87.5 ± 8.3	86.3 ± 4	94.7 ± 2.6	92.9 ± 2.8
8	68.7 ± 11.6	81.6 ± 4.6	75.5 ± 5.4	81.7 ± 2
10	No change	66.5 ± 6.5	29.4 ± 12.5	72.3 ± 6.7

Table 6. **Cumulative survival rates according to implant diameter**

Time (years)	Implant diameter (mm)	
	3.25 ($n=149$)	4 ($n=99$)
5	93.9 ± 1.9	97.9 ± 1.4
8	91.9 ± 2.2	96.5* ± 2
10	90.3* ± 2.7	No change

*$P=0.019$.

Table 7. **Cumulative success rates according to implant diameter**

Time (years)	Implant diameter (mm)	
	3.25 ($n=149$)	4 ($n=99$)
5	85.9 ± 2.8	95.9 ± 1.9
8	80.2 ± 3.4	78.6 ± 4.4
10	53.3 ± 7.1	58.3 ± 9.2

rate and smokers ($P=0.09$), and between survival rate and general health ($P=0.06$), where failures in ASA-2 status health patients (17.9%) were higher than that in healthy (ASA-1) patients (6.9%).

Implants of 13 and 15 mm in length had the highest survival rate (97.9% and 96.4%, respectively), which was statistically higher ($P<0.01$) than implants 8 and 10 mm in length (75% and 88.2%, respectively) (Table 4). The success criteria for 8, 10 and 15 mm implant lengths were 68.7%, 66.5% and 72.3%, respectively, and, only 29.4% for 13 mm (Table 5). The cumulative survival rate according to implant diameter was 90.3% for 3.25 mm and 96.5% for 4 mm ($P=0.019$) (Table 6), while the success rate was only 53.3% for 3.25 mm and 58.3% for 4 mm diameter samples (Table 7).

Clinical parameters

For all survival implants, the average crestal BL, the mean of mesial and distal sites, was 1.7 mm (SD ± 1.85) and that of PD, the mean of MB, DB, ML and DL sites of any given implant, was 3.26 mm (SD ± 1.5). At the distributed successful/non-successful defined implants, the average BL was 0.92 mm (SD ± 0.66) and PD was 2.79 mm (SD ± 1.14) for the successful, and 4 mm (SD ± 2.3) and 4.66 mm (SD ± 1.59), respectively, for the non-successful ones. GI for the survival group was 0.96 (SD ± 0.96). At the successful defined group, GI was 0.75 (SD ± 0.88) and increased to 1.57 (SD ± 0.94) at the non-successful one. A statistically significant difference was shown between successful and non-successful groups for BL, PD and GI ($P<0.001$). The average KM height was similar at all defined implant groups: 2.75 mm (SD ± 1.42 – survival), 2.8 mm (SD ± 1.42 – successful) and 2.6 mm (SD ± 1.45 – non-successful). Similarly, for mucosal marginal REC: 0.45 mm (SD ± 0.69) at the survival group, and 0.43 (SD ± 0.65) and 0.49 (SD ± 0.77) at the successful and non-successful groups, respectively (Table 8).

In the survival group, the Pearson's correlation test revealed a correlation between BL and GI ($P<0.001$; $R=0.48$) and to PD ($P<0.001$; $R=0.66$), and between GI and PD ($P<0.001$; $R=0.63$). A negative correlation was shown between GI and KM ($P=0.011$; $R=-0.17$), and GI to REC ($P<0.001$; $R=-0.28$). An increase in GI parameter also correlated to an increase in REC ($P=0.001$; $R=0.23$). The clinical parameters of the successful group showed correlations between BL and GI ($P<0.001$; $R=0.32$), and to PD ($P<0.001$; $R=0.5$). PD was positively correlated to GI ($P<0.001$; $R=0.59$) and negatively to REC ($P=0.03$; $R=-0.17$). REC was also negatively correlated to KM ($P<0.001$; $R=-0.33$). A similar pattern was observed in the non-successful group: BL to GI ($P=0.001$; $R=0.44$) and to PD ($P<0.001$; $R=0.49$). Additionally, GI positively correlated to PD ($P<0.001$; $R=0.46$) and negatively to KM ($P=0.01$; $R=-0.35$). REC was only correlated to GI ($P<0.001$; $R=0.46$) (Table 9).

Table 8. **Average clinical parameters of each defined group**

Clinical	Group		
Parameters	Survival – SD	Successful – SD	Non-successful -SD
BL	1.69 ± 1.85	0.92* ± 0.66	4.03* ± 2.29
PD	3.26 ± 1.5	2.79* ± 1.14	4.66* ± 1.59
GI	0.96 ± 0.96	0.75* ± 0.88	1.57* ± 0.94
KM	2.75 ± 1.42	2.8 ± 1.42	2.6 ± 1.45
REC	0.45 ± 0.69	0.43 ± 0.65	0.49 ± 0.77

*$P<0.01$.
BL, radiographic crestal bone loss (mm); PD, probing depth (mm); GI, gingival index; KM, keratinized mucosa height (mm); REC, marginal mucosal recession (mm).

Table 9. **Correlations between clinical parameters**

Inter-indices correlation	Survival (*R*)	Successful (*R*)	Non-successful (*R*)
BL/PD	0.66*	0.5*	0.49*
BL/GI	0.48*	0.32*	0.44*
PD/GI	0.63*	0.59*	0.46*
PD/KM			
PD/REC		−0.17**	
GI/KM	−0.17**		−0.35**
GI/REC	0.23*		0.46*
KM/REC	−0.28*	−0.33*	

*$P<0.01$.
**$P<0.05$.
BL, radiographic crestal bone loss; PD, probing depth; GI, gingival index; KM, keratinized mucosa height; REC, marginal mucosal recession.

Discussion

The success rate of HA-coated implants tends to decline significantly over a 10-year period, mostly evident between 5 and 10 years in function. Since survival criteria do not comprise level of bone support, i.e., level of osseointegration, survival percentages through the years decreased only slightly. The final survival and success percentage rates should be interpreted with caution since the Kaplan–Meier analysis does not consider drop-out cases (seven implants), where no data are reported. At most, the final results could have been worse, approximately 2.5%. However, it would not affect the main outcome: that at 10 years, the survival rate was over 90%, and the success rate was only slightly over 50%. The present study supported the results of Wheeler (1996), Watson et al. (1998) and Tinsley et al. (2001). The latter study also emphasized that the success rate had decreased significantly during their late period (4–6 years) of function.

Contradictory findings have been reported (Lambert et al. 2000; Jeffcoat et al. 2003), at least on the relatively short-term success rate (3 and 5 years, respectively). Lee et al. (2000) conducted a long-term meta-analytic review of HA-coated implants of different manufacturers with apparently different qualities of HA coating production. Cumulative survival rates for the studies in which life table analysis with follow-up of 8 years was used ranged from 79.2% to 87%.

Another HA-coated cylindrical implant (IMZ) was evaluated for 5 years (Mau et al. 2002). The cumulative success rate was only 69.5%, and was found to be inferior to a titanium plasma-flame surface (82.2%). Recently, Schwartz-Arad et al. (2004) have shown that HA-coated implants exhibit higher crestal BL than non-coated implants.

Apparently, chemical bonding (de Groot et al. 1987; Geesink et al. 1988) influences the high success rate at least in these short-term evaluations (Geurs et al. 2002). However, in long-term evaluations, this could become an obstacle. While no difference was observed in the plaque-induced environment around different implant surfaces (Morris et al. 2000; Mau et al. 2002; Shibli et al. 2003), the rigid bio-integration factor, which could elevate overstressing and subsequent bone resorption, was suggested to occur (Ichikawa et al. 1996). Another possible factor could be the fate of the long-term connection between the coating and titanium body (surface). A significant difference was shown morphometrically on bone–implant contact to HA-coated implants in different periods of post-insertion (Gottlander & Albrektsson 1991). In a later study (Gottlander et al. 1997), the same group suggested macrophage-induced resorption, which would probably affect bone–implant contact measurements. Under light and scanning electron microscopy, detached hydroxapatite particles could also be seen (Ogiso et al. 1998; Piattelli et al. 1999; Rohrer et al. 1999). In a methodological scanning electron microscopy of failed implants, chemical changes within the coating followed by HA thickness reduction were observed (MacDonald et al. 2000).

Microscopic changes on the coating characteristics and the surrounding tissue relationship (coating dissolution, decreasing and weakening of the binding) could have an impact on long-term stabilization and quality of osseointegration. In their critical review, Ong & Chan (2000) discussed the possible contributory factors toward failure, with emphasis on the coating–substrate interfacial fracture. When 10 HA-coated acetabular cups retrieved from hip replacement were evaluated, there was a significant degradation of the HA coating and subsequent soft-tissue intervention (Rokkum et al. 2003). By comparing six manufactured coatings, Paschalis et al. (1995) found that in the same environment HA coating varied in their reaction.

Levy et al. (1997) found no correlation between clinical parameters, such as plaque and bleeding indices and crestal bone resorption, whereas Teixeira et al. (1997a) observed a correlation between mucosal inflammation and marginal bone resorption around these implants. In the present study, a correlation was found between crestal bone resorption and GI and PD, and between GI and PD, for survival, successful and non-successful defined implant groups. There was also a low success rate after 10 years as shown in the anterior mandible. Apparently, the proximity of the lingual salivary gland orifices with subsequent calculus build-up and occasionally a lack of masticatory mucosa around the implants, mainly lingually, contribute to

crestal bone resorption around these implants and a poor success rate outcome. According to the Pearson correlation test, regarding soft-tissue status around the non-successful group, an increase in the GI parameter was seen, which coincided with a reduction in KM height and an increase in marginal REC. Additionally, a distinguishable observation was noted between successful and unsuccessful implants with regard to BL, GI and PD indices. Therefore, the oral environment and osseointegrated implants should be taken into consideration. A comparative histomorphometric study in rabbit tibia (Oosterbos et al. 2002) has shown that in the presence of bacteria an infection developed more easily in HA-coated implants than in non-coated ones. Furthermore, this experimental peri-implant infection reduced bone/implant contact, which subsequently affects osseointegration. However, it should be kept in mind that the oral cavity is a completely different environment in the presence of saliva, oral microorganisms and physiologic functional loading.

Implant dimensions are another factor. Short porous-surface implants, 7–10 mm in length, function in a predictable manner (Deporter et al. 2002). Recently, similar data were reported with sintered porous-surfaced implants (Hagi et al. 2004). HA-coated implants were suggested primarily for short fixtures (Biesbrock & Egerton 1995; Teixeira et al. 1997b). Others (Winkler et al. 2000, Schwartz-Arad et al. 2004) have shown a significant difference in survival rate between longer implants compared with shorter ones. In the present study, a correlation between implant length and diameter to survival rate was also recognized. The low success rate after 10 years in implants 13 mm in length (29.4%) should be interpreted with caution since the standard error comprised two digits. Probably, the meticulous terms of success rate definition caused a higher rate of failures such that implant length and diameter were not determinantal factors in that type of implant.

In conclusion, while short-term (up to 5 years) HA-coated implants showed a high success rate based on any given criteria, long-term evaluation (5–10 years) showed a significant reduction according to success terms, although these implants were considered to be surviving and in function.

Acknowledgements: The authors wish to thank Ms Ilana Gelerenter for statistical analysis, and Ms Rita Lazar for editorial assistance.

Résumé

Le but de cette étude a été de différencier entre les définitions de succès et de survie (Albrektsson et al. 1986; van Steenberghe et al. 1999) de prothèses sur implants recouverts de HA. Deux cent quarante-huit implants placés chez 62 patients et en fonction depuis cinq à dix ans ont été évalués. Les différentes longueurs des implants étaient de 8 (7%), 10 (29%), 13 (30%) et 15 mm (34%). Les diamètres étaient de 3.25 (60%) et 4 mm (40%). La profondeur de poche (PD), l'indice gingival (GI), la hauteur de la muqueuse kératinisée (KM) et la récession (REC) ont été mesurés. Les radiographies périapicales ont été prises pour estimer la quantité de résorption osseuse crestale (BL), en mésial et en distal à l'aide d'un verre grossissant millimétrique. Seul les implants qui suivaient des critères du taux de réussite d'Albrektsson et al. en 1986 étaient considérés comme des réussites. Tous les autres implants étaient placés dans les groupes sans succès. Toutes les prothèses sur implants étaient définies comme les survivantes. Un taux de survie cumulatif était après cinq et dix années de respectivement 94% et 93%. Les taux de succès cumulatif étaient de respectivement de 90% et 54%. Les implants de 13 et 15 mm de longueur (respectivement de 98 et 96%) avaient le taux de survie le plus haut qui était supérieur à celui des implants d'une longueur de 8 à 10 mm (respectivement 75%, $P<0.01$ et 88,%). Les taux de survie des implants d'un diamètre de 4 mm comparé à ceux de 3.25 mm étaient respectivement de 97% et 90% ($P=0.019$). Les BL moyennes étaient de 1.7, 0.92 et 2.79 mm pour les groupes d'implants définis avec survie, succès et sans succès. Les PD étaient respectivement de 3.26, 2.79 et 4 mm et les GI de 0.96, 0.75 et 1.57. Ces mesures étaient statistiquement différentes entre les groupes. Les mesures KM et REC montraient des scores semblables pour tous les groupes. Une corrélation a été trouvée entre les implants avec succès et sans succès pour les scores de GI et PD ($P<0.001$ pour les deux). Une observation différente entre le taux de succès et le taux de survie a été mise en lumière particulièrement pour les observations à long terme. La longueur d'un implant ainsi que son diamètre ont une influence sur le taux de survie. Les scores des paramètres cliniques exprimaient une influence sur l'état de l'implant.

Zusammenfassung

Ziel: Man versuchte zu differenzieren zwischen den Definitionen der berlebensrate und der Erfolgsrate (Albrektsson et al. 1986; van Steenberghe et al. 1999) bei Rekonstruktionen, die auf HA-beschichteten Implantaten ruhen und in Funktion sind.

Methoden: Man untersuchte insgesamt 248 Implantate (62 Patienten), die 5 bis 10 Jahre in Funktion waren. Die Verteilung der Implantatlngen war die folgende: 8 mm (6.5%), 10 mm (29.4%), 13 mm (30.2%) und 15 mm (33.9%). 60.1% der Implantate hatten einen Durchmesser von 3.25 mm und 39.9% einen von 4 mm. Man mass die Sondierungstiefen (PD), den Gingivalindex (GI), die Breite der keratinisierten Gingiva (KM) und die Rezessionen (REC). Zudem nahm man periapicale Rntgenbilder auf, um mit Hilfe einer Lupe (× 8) mit Millimeterskala das Ausmass der crestalen Knochenresorption (BL) mesial und distal abzuschtzen. Nur diejenigen Implantate, welche die Erfolgskriterien (Albrektsson et al. 1986) erfllten, wurden als erfolgreich gewertet; alle anderen Implantate, auch wenn sie in Funktion standen, nicht. Alle implantatgetragenen Rekonstruktionen in Funktion definierte man als solche mit positiver berlebensrate.

Resultate: Die kumulative berlebensrate nach 5 und 10 Jahren betrug 94.4% und 92.8%. Die kumulative Erfolgsrate betrug 89.9% und 54%. Die Implantate mit den Lngen 13 und 15 mm hatten die grsste berlebensrate (97.9% beziehungsweise 96.4%), sie war grsser als bei Implantaten von 8 und 10 mm Lnge (75%; $P<0.01$, beziehungsweise 88.2%). Die berlebensrate von Implantaten mit 4 mm Durchmesser betrug 96.5%, bei solchen mit 3.25 mm Durchmesser 90.3% ($P=0.019$). Der durchschnittliche BL betrug 1.7 mm, 0.92 mm und 2.79 mm fr die als berlebend, erfolgreich und nicht erfolgreich definierten Implantatgruppen. Die PD war 3.26 mm, 2.79 mm und 4 mm; der GI betrug 0.96, 0.75 und 1.57. All diese Messungen zeigten zwischen den verschiedenen Implantatgruppen einen statistisch signifikanten Unterschied. Die Messungen der KM und der REC zeigten waren bei allen Gruppen hnlich. Sowohl in der Gruppe der erfolgreichen wie auch der nicht erfolgreichen Implantaten zeigte sich eine Korrelation zwischen den Werten fr den GI und die PD ($P<0.001$ bei beiden Gruppen).

Zusammenfassung: Speziell bei lnger dauernden Beobachtungsperioden verzeichnete man vergleichbare Beobachtungen bei den berlebens- und Erfolgsraten. Sowohl Implantatlnge wie auch -durchmesser haben einen Einflsse auf die berlebensrate. Die klinischen Parameter wiederspiegelten den definierten Status des Implantates.

Resumen

Intención: Diferenciar entre las definiciones de supervivencia y de éxito (Albrektson et al. 1986; van Steeberghe et al. 1999) de prótesis funcionales de implantes cubiertos de HA.

Métodos: Se evaluaron un total de 248 implantes (62 pacientes), de 5 a 10 años en función. La distribución de la longitud de los implantes fue 8 (6.5%), 10 (29.4%, 13 (30.2%), y 15 mm (33.9%). El diámetro fue de 3.25 (60.1%) y 4 mm (39.9%). Se midió la profundidad de sondaje (PD), el índice gingival (GI), la altura de la mucosa queratinizada (KM) y la recesión (REC). Se tomaron radiografías periapicales para estimar la cantidad de reabsorción del hueso crestal (BL), por mesial y distal, con la ayuda de una lupa con escala milimétrica (× 8). Solo los implantes que cumplieron los criterios de éxito de Albrektson et al. 1986) se consideraron con

éxito. Todos los demás implantes funcionales se asignaron al grupo sin éxito. Todas la prótesis de implantes funcionales se definieron como aquellas con éxito.

Resultados: El índice de supervivencia acumulado tras 5 y 10 años fue del 94.4% y del 92.8%, respectivamente. El índice de éxito acumulado fue del 89.9% y del 54%, respectivamente. Los implantes de longitudes de 13 y 15 mm (97.9% y 96.4%, respectivamente) tuvieron los índices de supervivencia más altos, el cual fue más alto que los de 8 y 10 mm de longitud (75%, $P<0.01$ y 88.2%, respectivamente). El índice de supervivencia de los implantes de 4 mm de diámetro comparado con los de 3.25 mm fue de 96.55 y 90.3%, respectivamente ($P=0.019$). La BL media fue de 1.7, 0.92 y 2.79 mm para los grupos definidos como de supervivencia, de éxito y sin éxito. La PD fue de 3.26, 2.79 y 4 mm, y el GI fue de 0.96, 0.75 y 1.57, respectivamente. Estas mediciones fueron estadísticamente diferentes entre los grupos de implantes. Las mediciones de la KM y la REC mostraron valores similares para todos los grupos. Se mostró una correlación entre implantes con éxito y sin éxito en los valores de GI y de PD ($P<0.001$ en ambos).

Conclusión: Se notó una observación distinguible entre índice de supervivencia e índice de éxito particularmente en observaciones a largo plazo. La longitud y el diámetro del implante tienen influencia en el índice de supervivencia. Los valores de los parámetros clínicos expresaron una influencia en los estatus de implantes definidos.

要旨

目的：HA コーティングを施したインプラント補綴物の存続率と成功率の定義を区別すること（**Albrektsson et al. 1986; van Steenberghe et al.1999**）

方法：５年から１０年機能しているインプラント合計２４８本（患者６２名）を評価した。インプラント長の分布は、８ｍｍ（６．５%）、１０ｍｍ（２９．４%）、１３ｍｍ（３０．２%）及び１５ｍｍ（３３．９%）であった。直径は３．２５ｍｍ（６０．１%）と４ｍｍ（３９．９%）であった。プロービング深さ（**PD**）、歯肉インデックス（**GI**）、角化粘膜の高径（**KM**）と退縮（**REC**）を測定した。ペリアピカル**X**線を撮影し、ミリメートルの目盛付き拡大鏡（**X8**）を用いて、近遠心面の歯槽頂の骨吸収量（**BL**）を推定した。成功率の基準（**Albrektsson et al. 1986**）を満足するインプラントのみを成功とみなした。機能しているインプラント補綴物は全て存続していると定義した。

結果：５年後及び１０年後の累積存続率は、各々９４．４%と９２．８%であった。累積成功率は各々８９．９%と５４%であった。１３ｍｍと１５ｍｍ長のインプラントの存続率は、最も高く（各々９７．９%と９６．４%）、８ｍｍ長と１０ｍｍ長のインプラント（各々７５%、ｐ＜０．０１と８８．２%）よりも高かった。直径４ｍｍと３．２５ｍｍ径のインプラントの存続率は互いに類似しており、各々９６．５%と９０．３%（ｐ＝０．０１９）であった。平均 **BL** は、存続群、成功群、非成功群で各々１．７、０．９２及び２．７９ｍｍであった。**PD** は各々３．２６、２．７９、４．０ｍｍであり、**GI** は０．９６、０．７５及び１．５７であった。インプラント群間でこれらの測定値は統計学的な有意差を示した。**KM** と **REC** の測定値は、全ての群で類似していた。成功群と非成功群の **GI** と **PD** のスコアには相関性が認められた（両方ともｐ＜０．００１）。

結論：存続率と成功率の間には、特に長期観察において顕著な違いが認められた。インプラント長と直径は存続率に影響を及ぼした。臨床的パラメータのスコアは、インプラントの結果の定義に影響を及ぼしていた。

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