Implant Treatment in the Edentulous Maxillae: A 15-Year Follow-Up Study on 76 Consecutive Patients Provided with Fixed Prostheses

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ABSTRACT

Background: Few long-term follow-up studies are available on implant treatment based on patient level data related to time.

Purpose: The aim of this study was to report 15-year patient-based data in relation to time of follow up after treatment with fixed prostheses supported by implants in the edentulous upper jaw.

Materials and Methods: Seventy-six edentulous consecutive patients, provided with 450 turned Brånemark implants, were followed up with regard to maintenance, complications, and radiographs taken during the follow-up period.

Results: Forty-four patients provided with 247 implants were lost to follow up. Patients followed up for 15 years showed as a group a trend of better implant survival than patients lost to follow up ($p > .05$). Altogether, 37 implants and 5 fixed prostheses failed during the follow-up period. Most implants were lost at abutment surgery ($n - 15$) and another nine during the first year of function. The 15-year implant and fixed prosthesis cumulative survival rate was 90.9 and 90.6%, respectively. Resin veneer fractures caused most problems, more frequent in the earlier stage while severe wear increased in the later stage of follow up. No implant fractures or loosening of abutment/bridge locking screws were noted. The mean marginal bone loss was 0.5 mm (SD 0.47) after 5 years, followed by only minimal average changes during the following years. No radiographic parameter showed any time-dependent relationship. The percentage of patients presenting at least one implant with more than 2.0-mm bone loss was 4.9% in the interval from 0 to 5 years and 4.0% between 10 and 15 years. Only 1.3% of implants showed >3.0 mm accumulated bone loss after 15 years.

Conclusion: Implant treatment in the edentulous upper jaw functions well in a 15-year time perspective, but an insignificant trend of higher implant failures was observed for patients lost to follow up. Besides wear and fractures of veneers, no other parameter showed any time-related relationship, indicating an increased risk for more complications during later stages of follow up. However, accumulation of smaller amount of bone loss during the years resulted in an increasing number of implants and patients with bone levels below the third thread, which could be speculated to increase future maintenance after 15 years.

KEY WORDS: bone loss, complications, edentulism, failures, fixed prostheses, implants, long-term follow up, upper jaw

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Implant treatment in the edentulous jaw is a routine and well-documented procedure today, also in long-term follow-up situations over 10 years and more.[1–11] However, documentation on this treatment modality has mostly focused on implant and prosthesis survival, especially observed in the lower jaw, and results have been presented as mean values, rather than reporting on the result on a patient-level basis. Since the mean values of large groups of patients tend to disguise the maintenance of the individual patients, information on the

prevalence of patients with complications and identification of risk patients may be compromised by using this approach.

In a recent cross-sectional study, Fransson and colleagues[12] reported on a patient-level basis the prevalence of continuous bone loss at implants in a large group of implant patients followed up for 5 to 20 years. They reported that about 28% of the patients (about 12% of implants) presented at least one implant that showed "continuous bone loss" of more than 2 mm after 5 years or more in function. However, magnitudes of bone loss for individual implants, or whether patients with bone loss are more frequently found after longer follow-up time intervals (up to 20 years) were not analyzed in this publication. Since time itself may play an important role in the maintenance of implant restorations,[8] the observations of Fransson and colleagues[12] nevertheless further enlighten the significance of analyzing treatment results from an individual patient level as well as focus on the aspect of possible time-dependent changes.

The purpose of this study was to report the performance of treatment of fixed prostheses supported by implants in the edentulous upper jaw during 15 years of follow up, focusing on the result of the individual patient and the possible changes and complications related to the time of follow up.

MATERIALS AND METHODS

This study covers all patients, consecutively provided with fixed prostheses supported by implants in the edentulous upper jaw at one clinic (The Brånemark Clinic) from January 1986 to December 1987. The present group of patients has earlier been accounted for in a previous 5-year follow-up study, then referred to as the "fixed prosthesis group."[13]

TABLE 1 Number of Teeth, Complete Dentures (CDs) and Fixed Implant-Supported Prostheses (FIPs) in the Opposing Lower Jaw

	Number of Teeth				Prostheses	
	1–4	6	8–9	10–12	CDs	FIPs
Lower Jaws*	3	10	11	29	1	18
RPDs	3	6				

The number of removable partial dentures (RPDs) is also given.
*Information not available for four patients.

A total of 76 patients were included in the study group, and 48 of the patients were males. The mean age at implant surgery was 60.1 years (SD 11.6 years), and their ages ranged from 32 to 75 years.

No general health problems of somatic character were reported for 37 patients (48.7%). However, nine of these patients reported psychological-related problems. Twenty patients were medicated for cardiovascular problems, three patients had asthma, two patients were medicated for diabetes, and 14 patients had other general health problems. Information on smoking habits was available for 34 patients (44.7%), where 21 patients (61.8%) were smokers.

The time of edentulism in the upper jaw before implant treatment was on an average 13.3 years (SD 12.2 years), with a range from 0 to 48 years. Dentition in the opposite jaw at the time of implant placement is presented in Table 1.

Bone quality and bone resorption of the treated jaws were classified at the time of first surgery according to the index described by Lekholm and Zarb[14] (Table 2). In total, 450 turned titanium Brånemark implants (Nobel Biocare AB, Göteborg, Sweden) were placed according to a two-stage standard surgical protocol[15]

TABLE 2 Distribution of Patients with Regard to Bone Quality and Bone Resorption According to Lekholm and Zarb[14] at Implant Placement

Bone Quality	Bone Resorption					
	1	2	3	4	5	Total
1			1			1
2		3 (1)	2 (1)			5 (2)
3	3	21 (5)	28 (7)	3 (2)	1	56 (14)
4	1	1 (1)	6 (2)	3	1 (1)	12 (4)
Total	4	25 (7)	37 (10)	6 (2)	2 (1)	74* (20)

Number of patients with implant failures within brackets.
*Information not available for two patients recorded with implant failures.

TABLE 3 Number of Placed and Lost Implants

	Number of Implants					
	7 mm	10 mm	13 mm	15 mm	18 mm	Total
Placed	111	199	107	28	5	450
Lost	18	18	1	—	—	37

(Tables 3 and 4). On an average, 5.9 implants (SD 0.60 implants) were placed in each jaw, one provided with eight implants, five with seven, sixty-one with six, six with five, and three with four implants each.

The abutment connection surgery was performed after a healing period of 6 to 8 months. Thereafter, all patients were treated with fixed prostheses, designed with a cast type III gold alloy framework supporting conventional acrylic resin teeth.[13,16] The prostheses included 10 to 12 teeth with posterior cantilevers of 7–12 mm in length. After insertion and final tightening of the bridge locking screws 2 to 6 weeks later, the patients were scheduled for annual checkups only. However, all patients were encouraged to contact the clinic whenever they had problems with their prostheses.[13,17] Intraoral apical radiographs were taken on routine basis at the Radiological Specialist Clinic (Public Dental Health Service, Göteborg, Sweden) at the time of prosthesis insertion, after 1, 5, 10, and 15 years in function.

Data were retrieved from patients' files, also including all problems encountered during the follow-up period according to protocols described earlier.[13] Bone loss was measured in relation to the threads of the implants to the closest 0.3 mm on the mesial and distal sides of the implant. A mean value between the mesial and distal sides was used for each implant. The reference for these measurements was the fixture/abutment junction (FAJ), placed 0.8 mm coronal of the implant reference point used in the previous study.[13,18]

The criteria for success according to Albrektsson and colleagues[19,20] were also used to define implant performance, allowing for 1.0-mm bone loss during the first year of function followed by a maximum 0.2 mm of bone loss for the following years.

In the present study, descriptive statistics and conventional life table analysis showing implant and prosthesis cumulative survival rates (CSRs) were utilized. Chi-square tests were used to compare groups of follow up with regard to difference in distribution of implant failures. The statistical significance was set to 5%.

TABLE 4 Life Table of Implants and Prostheses

	Number of Implants				Implant	Number of Prostheses			Prosthesis
	Implants	Dropout	Failure	New	CSR	Patients	Dropout	Failure	CSR
Surgery	450					76			
Abutment	435		15		96.7	76			100
First year	406	20	9		94.6	73	3		98.7
Second year	401	4	1		94.4	71	1	1	98.7
Third year	379	21	3	2	93.7	68	3		97.2
Fourth year	361	18			93.7	64	3	1	97.2
Fifth year	**350**	**10**	**1**		**93.4**	**62**	**2**		**97.2**
Sixth year	323	25	2		92.8	57	5		97.2
Seventh year	298	25			92.8	52	5		97.2
Eighth year	287	7	4		91.6	50	1	1	95.4
Ninth year	282	5			91.6	49	1		95.4
Tenth year	**255**	**26**	**1**		**91.2**	**44**	**5**		**95.4**
Eleventh year	220	34	1		90.9	37	5	2	90.6
Twelfth year	214	6			90.9	36	1		90.6
Thirteenth year	185	29			90.9	31	5		90.6
Fourteenth year	168	17			90.9	28	3		90.6
Fifteenth year	168				90.9	28			90.6
Total	**168**	**247**	**37**	**2**	**90.9**	**28**	**43**	**5**	**90.6**

CSR = cumulative survival rate.

TABLE 5 Distribution of Withdrawn Patients with Regard to Time and Reason for Withdrawal

Year of Withdrawal	Deceased	Moved	Health	Lost	**Total**
Surgery					
Abutment					
First	2		1		**3**
Second	1				**1**
Third	1	1		1	**3**
Fourth	2	1			**3**
Fifth	2				**2**
Sixth	1	4			**5**
Seventh	1	4			**5**
Eighth		1			**1**
Ninth	1				**1**
Tenth	3			1	**4**
Eleventh	3		2	1	**6**
Twelfth				1	**1**
Thirteenth	4			1	**5**
Fourteenth		1		2	**3**
Fifteenth					
Total	**21**	**12**	**3**	**7**	**43**

Unknown reason for withdrawal is recorded as "lost."

RESULTS

Patients Lost to Follow Up

Altogether, 43 patients (56.6%) were lost to follow up during the study period (Tables 4 and 5). With exclusion of 21 deceased patients, the dropout rate was 28.9% for 15 years. The most common reason for withdrawal was, besides deceased patients, that some had moved from Göteborg and could not attend annual checkups (see Table 5). Distributions of implants lost to follow up are presented with regard to groups of dropout in Table 6.

Implant and Prosthesis Stability

Thirty-seven of 450 inserted implants were found loose and removed during the 15-year follow-up period in 22 patients (see Tables 3, 4, and 6). Fifteen implants (3.3%) were loose before prosthesis placement in 14 different patients. Thereafter, 22 loaded implants were removed during the following years in 13 patients. Patients followed up for the entire period lost altogether four implants (2.8%), three of them before prosthesis placement (see Table 6). Withdrawn patients lost altogether 17 implants (6.9%) before being excluded from the study after on an average 7.1 years of follow up (see Table 6). Differences in distributions of implant failures between different subgroups of follow up did not reach significant levels ($p > .05$).

The overall mean failure rate was 0.49 implants (SD 0.95) per patient during 15 years of follow up. For those patients followed up for the entire period (including also failed patients), the mean failure rate was 0.53 implants (SD 1.14) per patients. For loaded implants, the corresponding mean failure rates were 0.29 (SD 0.78) and 0.38 (SD 0.98) implants per patient, respectively. Fifty-four patients had no implant failures reported, 14 patients had one failure, three patients had two and three implant failures each, and two patients had four implant failures reported. Six of the 33 patients followed up for 15 years, including also the patients recorded as complete failures, had implant failures (18.2%).

Most implants were lost before prosthesis placement and during the first year in function (see Table 4).

TABLE 6 Distribution of Patients (Total/Patients with Failures) and Implants with Regard to Groups of Follow Up

		Years of Follow Up				Implants		
Group of Follow Up	Patients	Minimum	Maximum	Mean	SD	Placed	Lost	%
Followed-up 15 years	**28**/4		15	15	0.00	172	**4**/3	2.8
Failed prostheses	**5**/5	1	10	5.5	4.43	27	**16**/2	59.3
Total dropout	**43**/14	0	14	7.1	3.97	251	**17**/10	6.9
Deceased	**21**/4	0	12	6.8	4.19	121	**7**/5	5.8
Dropout excluding deceased	**22**/9	0	13	7.3	3.82	131	**10**/5	9.5
Moved from Göteborg	**12**/4	2	13	5.8	2.67	70	**5**/3	7.1

Relationship of lost implants (**total**/lost at second surgery) is calculated as a percentage of total number of lost implants in relation to placed implants (%).

TABLE 7 Total Number of Clinical Problems Reported During the Follow-Up Period

	Follow-Up Period		
	0–5 Years (68)	6–10 Years (50)	11–15 Years (32)
Diction	30	—	—
Fractures			
Resin veneers	73	71	14
Implants	—	—	—
Abutment/Gold screws	—	—	1
Framework	1	—	—
Loose abutment/Gold screw	—	—	—
Mucosa related			
Hyperplasia/Inflammation	31	8	5
Fistulae	13	2	—
Prosthesis related			
Redesign	20	—	2
New prosthesis	1	1	1
Gingival prosthesis	8	—	—
New veneers due to wear	—	1	4
Severe wear	—	1	10
Temporomandibular joint	6	—	1

Mean number of patients followed up in the interval is given within parentheses.

Thereafter, only 13 implants were lost during the following 14 years in function. Ten of these late failures were observed in three of the failed patients accounted for above and the remaining three lost implants were observed in three other patients. Eighteen lost implants were of 7 and 10 mm each, and one lost implant was 13 mm (see Table 3). The 15-year implant CSR was 90.9% (see Table 4).

One female and four male patients lost their prosthesis due to implant failures, thereafter provided with removable overdentures supported by the remaining one to three implants each. Two of these patients had been treated with predominantly short 7-mm implants (four out of four and four out of six implants, respectively), and another two of these patients had a history of trauma to the maxillary implant prosthesis prior to failure. These patients/prostheses have been recorded as failures (see Table 4). The 15-year fixed prosthesis cumulative success rate was 90.6% (see Table 4).

Maintenance

The mean number of clinical appointments per year was highest during the first year in function (mean 6.1, SD 3.56) followed by a decreasing average of mean number of appointments from 2.2 (SD 2.59) to 1.5 (SD 1.48) after 5 years. Thereafter, the mean number of appointments ranged between 1.2 and 2.0 appointments per year, with no systematic trend of increase or decrease during the following 10 years.

Resin veneers caused most problems and maintenance during the follow-up period, both shown as fractures as well as in the later period as severe wear of the veneers (Table 7). On the other hand, other mechanical complications as fractures of implant components or loosening of gold and abutment screws were low (see Table 7). Instead, the second most common problem was related to the mucosa, shown as hyperplasia and inflammation in the peri-implant soft tissue.

Radiographs

The percentage of implants presenting the marginal bone level to be more than 3.0 mm below FAJ (at or below the third thread of the implant) increases from 8.7% after 1 year to 14.0% after 15 years (Table 8). The corresponding number of patients with at least one implant with bone level more than 3.0 mm below FAJ increases from 23.9% after 1 year to 44.0% after 15 years.

TABLE 8 Mean Marginal Bone Level in Relation to Fixture/Abutment Junction (FAJ) During the Follow-Up Period

	Follow-Up Periods			
	0–1 year	0–5 years	0–10 years	0–15 years
Patients	71	62	41	25
Implants	402	350	238	150
	Bone Level in Relation to FAJ (mm)			
Mean	1.8	2.0	2.0	2.1
SD	0.60	0.58	0.61	0.58
Bone Level to FAJ (mm)	Number of Implants (%)			
<0.9	65 (16.2)	47 (13.4)	36 (15.1)	17 (11.3)
0.9–1.9	208 (51.7)	163 (46.6)	100 (42.0)	63 (42.0)
2.0–3.0	94 (23.4)	109 (31.1)	70 (29.4)	49 (32.7)
3.1–3.8	25 (6.1)	24 (6.9)	25 (10.5)	15 (10.0)
>3.8	10 (2.5)	7 (2.0)	7 (2.9)	6 (4.0)
Number of Patients with 0/1/2/3/ > 3 Implants with Bone Level ≥3 Threads to FAJ				
	54/8/3/4/2	43/10/6/3/—	23/11/3/1/3	14/6/2/1/2

Percentage of patients is given within parentheses.

The average bone loss was 0.4 mm (SD 0.31 mm) after 1 year, and 0.5 mm (SD 0.47 mm) after 5 years (Table 9). Thereafter, only small changes of the average level of bone loss could be observed after 10 and 15 years, respectively (see Table 9). The average bone loss between 5 and 10 years as well as between 10 and 15 years also showed only minimal changes (see Table 9).

The percentage of implants showing more than 2.0-mm bone loss during the first 5 years was 2.0%, 4.7% after 10 years, and 2.0% after 15 years (see Table 9). The corresponding number of patients with at least one implant with more than 2.0-mm bone loss was 4.9% after 5 years, 24.4% after 10 years, and 8.0% after 15 years. After 15 years in function, 1.3% of the implants showed more than 3.0-mm bone loss. No signs of increased incidence of bone loss could be observed in the later 5-year intervals after 5 years of follow up (see Table 9), and no relationship was found between the age of the patient and bone loss over time.

Considering the radiographic criteria for successful implants of Albrektsson and colleagues,[19,20] another ten, three, and one implants should be denoted as only "surviving implants" since they showed more than 1.8-, 2.8-, and 3.8-mm bone loss after 5, 10, and 15 years, respectively. The corresponding cumulative success ratio for implants was then calculated to 89.8, 88.2, and 86.8% during the follow-up period, respectively.

DISCUSSION

The results of the present 15-year follow-up study of edentulous patients treated with fixed prostheses supported by turned osseointegrated implants, placed according to a two-stage surgical procedure, demonstrated an implant and fixed prosthesis survival/success rate of 90.9 and 90.6%, respectively. The results also indicate a mean marginal bone loss of 0.5 mm (SD 0.59) during the follow-up period shown as most bone loss during the first year and then followed by a more or less steady state for the following years. Thereby, the overall treatment outcome confirms the good long-term results that have been reported in previous studies on implant treatment over 10–20 years.[1–11]

Altogether, 56.6% of the included patients were lost to follow up due to various reasons during 15 years (see Tables 5 and 6). This figure of lost patients is higher than earlier long-term followed-up implant groups,[1,2,9,10] but comparable to others.[8,21,22,23] However, many earlier long-term follow-up groups cover pioneer implant patients,[1,2,9,10] while the present group represents patients treated more on a routine level. With a treatment

TABLE 9 Mean Marginal Bone Loss and Distribution of Implants and Patients with Regard to Bone Resorption During Different Periods of Follow Up

	Follow-Up Periods (years)					
	0–1	0–5	0–10	0–15	5–10	10–15
Patients	70	61	41	25	41	25
Implants	398	346	238	150	238	150
	Bone Loss (mm)					
Mean	0.4	0.5	0.6	0.5	0.0	0.1
SD	0.31	0.47	0.59	0.59	0.44	0.28
Bone Loss (mm)	Number of Implants (%)					
<0.1	148 (37.2)	113 (32.7)	70 (29.4)	57 (38.0)	134 (56.3)	100 (66.7)
0.1–1.1	218 (54.8)	179 (51.7)	112 (47.1)	66 (44.0)	88 (37.0)	48 (32.0)
1.2–2.0	27 (6.8)	47 (13.6)	45 (18.9)	24 (16.0)	14 (5.9)	1 (0.7)
2.1–3.0	5 (1.3)	5 (1.4)	8 (3.4)	1 (0.7)	1 (0.4)	1 (0.7)
>3.0	0	2 (0.6)	3 (1.3)	2 (1.3)	1 (0.4)	0
	Number of Patients with 0/1/2/3 Implants with > 2 mm Bone Loss During the Follow-Up Period					
	66/3/1/—	58/—/2/1	31/9/1/—	23/1/1/—	39/2/—/—	24/1/0/0

Percentage of patients is given within parentheses.

protocol on a more routine basis, used more than 20 years after the first implant patient was treated in Göteborg, motivation for bringing all patients that also have moved from the city back for checkups has certainly been reduced. Thirty-six of the lost patients (84%) are well-controlled dropout patients (see Table 5) (deceased, moved, sick), where the reasons for dropout can be referred to the relatively high mean age at first surgery, resulting in migration from the city in association to retirement and sickness and decease during this long period of follow up. Accordingly, the relatively low proportion of unaccounted dropout patients during 15 years of follow up (16%) that indicate comparable numbers of lost patients with other routine long-term follow-up studies[8,21,22,23] suggests that the present number of lost patients is within earlier acceptable levels.

Based on this assumption on expected number of lost patients, it is tempting to assume that the results from the examined group of patients at the termination of the study should not be expected to differ from the original included population.

However, the results also presented in Table 6 may suggest that patients that are healthy enough to survive and are cooperative enough to attend regular maintenance examinations during 15 years may perform better. This implies that health and lifestyle factors may be of importance in the very long-term maintenance of dental implants, and dropout groups should preferably be well accounted for when long follow-up periods are covered.

Already the first follow-up studies on implant treatment in the edentulous jaw showed a pattern of higher implant failure rates before loading and during the first year of function than during the following years of follow up.[1,2] The present results coincide well with these early reports of upper jaw treatment with no indications of an increasing number of failures at the end of the follow-up period. Since the overall average implant failure rate was 0.29/0.38 implants per patient ("total loaded"/"loaded 15 years") during 15 years of follow up, the present results also compare favorably with average tooth loss of 0.7–2.2 teeth per patient during the period from 10 to 17 years in a normal dentate population.[24–26]

For the patient, the main concern with implant failures is that it may jeopardize the function of the fixed prosthesis. In the present study, failures of loaded implants were found in altogether 13 patients (17.1%). Five of these patients lost their prostheses and resumed to a denture supported by the remaining implants.

None of these complete failure patients lost their implants and fixed prostheses due to a preceding continuous bone loss. Instead, trauma was probably associated in two of these failures. This incidence of implant failures again compares favorably with dentate persons where 35% of a normal 50-year-old population suffered tooth loss during 10 years of follow up, associated with deeper probing depth at the teeth in patients where failing teeth were observed.[24]

The average bone loss was calculated to 0.4 mm during the first year of function, followed by a low average bone loss for the following years (see Table 9), again in accordance with earlier implant follow-up studies.[1–11] Accordingly, the mean average bone loss was 0.5–0.6 mm after 5 to 15 years with very small average changes after the first year (see Table 9). This result is comparable with a normal dentate population where 0.4-mm bone loss was found at the teeth during 10 years of follow up.[24] However, in contrast to Hugoson and Laurell,[26] observing an increased incidence of progression of marginal bone loss at teeth in older age groups, no relationship between bone loss at implants and age of patients could be observed in the present study.

Bone loss during the different time intervals is also presented in Table 9, showing an early remodeling phase during the first year of function, followed by on an average a very stable situation. It can then be seen that the progression of bone loss for the major part of patients and implants is slow. Implants with significant and more rapid bone loss of 2 mm or more over the different 5-year periods are few and reach about 1–2% of the implant population. However, it is important to notice that even though the magnitude of average bone loss is low, the accumulation of bone loss may be significant by time (see Table 8), as also discussed by others.[8] Since exposed implant threads have been reported as a risk factor for mucosa trauma and increased bone loss,[15] the incidence of more implants with exposed threads in the present material by time may indicate a potential risk for future problems in a longer time perspective than 15 years.

With regard to the time factor, Baelum and Ellegaard[27] reported similar bone resorption pattern for two different implant system after 5 years, but after 10 years, one of the systems provided with the roughest implant surface showed a much higher incidence of severe bone loss and implant failure.[27] With respect to time, bone loss tends to level out on an average after the first year of remodeling in the present study, as in accordance with other publications.[1,4,8,9] Thereafter, average bone levels remain stable, and only individual implants show more pronounced bone loss (see Tables 8 and 9), with only 1.3% of implants showing more than 3.0 mm of accumulated bone loss during 15 years, also in accordance with other reports.[8] When analyzing the following 5-year periods after the first 5 years in function, a stable pattern of bone level and bone loss can be observed (see Table 9). Thus, there are no indications of changed bone resorption pattern in this material over a 15-year period, and accordingly, a time-dependent increase of risk of implant failure is not observed in the present material with turned implant surfaces, as reported for some other implants provided with other surfaces.[27,28] Instead, in accordance with other studies,[8,29] implant failures in the present study are observed in an early period, predominantly associated with shorter implants, placed in softer bone qualities (see Tables 2 and 3).

When it comes to the overall maintenance of the patients, two aspects come into focus, shown as biological aspects to maintain osseointegration, bone level, and the health of the peri-implant mucosa and mechanical aspects related to the veneering material of the prostheses (see Table 7). Hyperplasia, inflammation, and fistulae in close relation to implants can be observed, but the incidence seems to decrease by time (see Table 7). The problem with fractures of the resin veneers is a well-documented problem[13,30] that seems to increase by time as also wear of the material comes into the picture in the later stages of follow-up period as well (see Table 7). The protocol of cast frameworks and resin veneers was introduced in the late 1970s as a technique to reduce occlusal impact and risk for implant fractures.[31] Even though the implant was redesigned to become stronger, and the problem with implant component fractures thereby was basically solved during these early years (see Table 7), the laboratory protocol with resin veneers for screw-retained fixed full-arch implant prosthesis has been kept. The major reason for this is that the resin technique significantly reduces the amount of alloy for casting when severe resorption is present, thereby reducing cost and increasing precision of fit of frameworks.

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