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Survival Analysis of Wide-Diameter Implants in Maxillary & Mandibular Molar regions ; A Retrospective Study.

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Endosseous implants are used in the treatment of various types of tooth loss, and numerous long-term studies have demonstrated the excellent reliability of this method of treatment. However, the increase of implant failure are associated with inadequate quality and/or height of bone. At the end of the 1980s, Wide(>3.75mm) implants were initially used for managing these difficult bone situations. The recommended indications for its use included poor bone quality, inadequate bone height, immediate placement in fresh extraction sockets, and immediate replacement of failed implants. At the 2000s, wider implant (6.0mm and 6.5mm) were used in a few studies. Although good clinical outcomes have been reported in recent years, there is still a controversy on this topic.

Therefore, the purpose of this study was to estimate the survival rate of wide-diameter implants(6.0-8.0mm) in molar regions, evaluating the clinical outcome. In this study, 1135 RBM surfaced wide-diameter implants (Rescue™, MEGAGEN Co., Korea/ 595 maxillary, 540 mandibular) were placed in 650 patients (403 male, 247 female/age mean: 51.2±11.1 years, range 20 to 83 years). Of the total, 68.3% were used to treat fully or partially edentulous situations, including single-tooth loss and 31.7% were placed immediately after teeth extraction or removal of failed implants, of which all were in the molar regions. Implant diameter and length ranged from 6.0 to 8.0mm and from 5.0 to 10.0mm, respectively. The implants were followed for up to 42 months(mean: 14.6±9.5 months).

Of 1135 placed implants, 58 implants were lost. Among them, 53 implants were lost within 12 months after implant placement. The survival rate was 93.6% in the maxilla and 96.3% in the mandible, yielding an overall survival rate of 94.9%, for up to 42 months. As the result of Cox regression model, prosthetic type, sinus graft, and patient gender have an statistical significance on the implant survival rate in this study.

This study suggests that the use of wide-diameter implants would provide a predictable treatment alternative in posterior areas.

KEY WORDS

Wide-diameter implant, Retrospective study, Survival rate.

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Introduction

Dental implant treatment based on the phenomenon of osseointegration has been a widely used treatment modality and numerous scientific literature report very high long-term success rates[1]. However, the success rates vary according to bone condition at the implant site[2]. Poor bone quality or inadequate bone height are the major cause of implant failure[3, 4].

Since the late 1980s, wide implants (more than 4mm in diameter) have been utilized to improve the success rates in compromised bone[4]. Langer et al[5] in 1993 reported the use of 5mm diameter implants and currently the use of wider implants of 5.5mm, 6mm or up to 6.5mm diameter are gaining in popularity[5-9]. Although many of the earlier scientific literature reported a compromised success rate of wide implants[10-13], more recent studies report equally higher success rates as regular size implant. This positive change of results were related to advanced implant design, matured learning curve for the surgical technique, proper case selection and so on[4,7,8,14,15,24]. Wide implants had been initially used mostly to replace failed implants of regular diameter in the posterior region[5]. However its indications have become broader and it is used for immediate implant placement after extraction and also for the compromised bone condition[14-16].

Bone compromised situation resulting from sinus pneumatization or from vertical bone loss, have been treated surgically with sinus augmentation, mandibular nerve transposition, or horizontal/ vertical ridge augmentation. However, these invasive procedures may accompany side effects like infection, increased morbidity or paresthesia.

Also it requires more time, money and suffering for both the patient and the doctors. Use of short implant is regarded as an alternative to these surgical procedures.

Shorter length can be compensated with increased width[3]. Dental implants have become a popular treatment modality for more than 15 years in Korea and there also have been active scientific investigation regarding the success and survival rates of implants[17-19].

After the introduction of wider diameter implants, clinicians have more choice of implant dimension according to clinical situation. Wider implants are gaining more popularity, but scientific investigation of wider implants are absent both domestically and internationally. Therefore, this retrospective study aims at the survival rate of wider implants and we want to find out the major causes affecting the longevity of wider implants.

Materials and Methods

Patient Selection

The study population included patients who received Rescue ™ implants (Wider implants of more than 6mm in diameter with RBM surface, manufactured by MegaGen implant company) on molar areas of both the maxilla and/or mandible at MIR dental hospitals of Taegu and Kwangju, Korea between November of 2003 and April of 2007.

The total number of Rescue implants was 1,135 and 3 surgeons (1 from Taegu and 2 from Kwangju MIR dental hospital) of similar credentials placed them and the results were evaluated. Total number of patients was 650 and 403 were male and 247 were female. Age range was 20 to 83 (mean 51.2 years) (table 1).

Table 1. Distribution of Patients

Patient No.		650
Gender(M/F)		403/247
Age	20-29	21
	30-39	83
	40-49	78
	50-59	229
	60-69	103
	70-79	33
	80-89	3

The diameter of Rescue implant ranges from 6mm to 8mm and the length from 5 to 10mm. In this study, only those implants placed on molar areas of both maxilla and mandible were included. There were 595 (52.4%) Rescue implants on maxillary molar area and 540 (47.6%) on mandibular molar area (table 2).

Table 2. Distribution of Implants According to Location

Implant No.	**1135**
Maxilla	**595**
1st molar	284
2nd molar	311
Mandible	**540**
1st molar	217
2nd molar	323

The data was sorted and categorized according to age, gender, area (maxilla versus Mandible), grafted sinus versus natural sinus, implant diameters and length, extraction socket versus healed socket, single stage versus two stage surgical approach and single standing versus multiple implants splinted restoration (table 3 and 4).

Table 3. Distribution of Implants According to Length and Diameter

	Diameter(mm)				
Length	**6.0**	**6.5**	**7.0**	**8.0**	**Total**
5.0	9	15	6	1	31
6.0	8	12	22	8	50
7.0	25	53	140	25	243
8.5	50	88	260	62	460
10.0	69	83	164	35	351
Total	161	251	592	131	1135

Table 4. Distribution of Implants According to Placement Time, Surgery Stage, Sinus Graft, Hex Type and Prosthetic Type

Placement time	
Immediate	360
Delayed	775
Surgery stage	
1 stage	554
2 stage	581
Sinus graft (Maxilla)	
Sinus graft	268
Non-sinus graft	327
Hexagonal connection type	
External type	868
Internal type	267
Prosthetic type	
Single	375
Multiple	728

Prosth.: Distribute except the failed implant before delivery (single/ multiple)

Follow-up period ranged from 4 to 42 months. Implant loading was considered to be initiated after delivery of provisional restoration (table 5).

Table 5. Distribution of Implants according to Duration and Loading Period

Duration(months)	
0-12	613
13-24	333
25-36	109
37-42	80
Loading period(months)	
0-12	732
13-24	249
25-36	122

Method

- Surgical protocol and follow-up

In this study, traditional drilling method was not used. Instead, trephine drills were utilized to simplify the drilling sequence. After formation of the initial osteotomy with a trephine drill, it was finalized with a bone tap in the mandible. In the maxilla, sinus elevation procedures either with lateral window or crestal approach was done simultaneously with implant placement when available bone height was compromised because of sinus pneumatization or periodontal bone loss.

After placement of implants, an average of 5 months (1-18 months) of healing time was allowed. Then definitive restorations were placed. Within 1st year period, all patients were followed up every 3 months. 1 year after placement of implants, all patients were followed up every 6 months. During follow-up visit, every implant was examined for clinical mobility. Peri-implant soft tissue examination was done using a plastic probe and periapical radio-graphs were taken to see any change in bone level around the implant.

- Criteria for implant failure

In order to analyze implant survival rate, criteria set by Steenberg[20)] in 1999 was used to determine if the implant survived in function. When removing failed implants, relevant criteria (table 6) set by Misch[21)] in 1993 was used to determine clinical implant failure.

Table 6. Criteria for implant failure (proposed by Misch)

- Radiolucent zone around the implant, possibly resulted from over-heating of bone during fixture placement
- Mobility of the fixture, observed during uncovery or during healing abutment delivery showing failure of osseointegration
- Loss of sensation or constant presence of peri-implantitis or infection
- Gradual loss of peri-implant bone more than 50%
- Presence of pain upon chewing or tapping
- Breakage of fixture

- Statistical Analysis

All the relevant data was collected from each patient chart and stored using Microsoft Excel. Then data was arranged according to set criteria.

Computer program, SPSS v12.0 (SPSS Inc, Chicago, Illinois) was used for Chi square test (Fisher's exact test was used when sample size was less than 10) to investigate statistical significance ($p<0.05$).

Chi square test was done to analyze survival rate of implants under each specific variables to prevent possible effects from other variables. In reality, many variables influence each other and functions as confounding variables. By eliminating confounding variables, one can accurately measure the effect of one factor to the survival rate of the implant. In order to adjust other explanatory variables, Cox Regression model, which is a well recognized statistical technique for exploring the relationship between the survival of implant and several explanatory variables, was used.

Lastly, in order to measure survival rate under different time period after implant placement, Life table method and Kaplan-Meier survival rate analysis were used.

Results

Survival rates

Among 650 patients, 52 patients experienced failure and among 52 patients, 6 patients had 2 Rescue implant failures. Total of 58 Rescue implant failed among total of 1135 Rescue implants placed. During follow-up period of up to 42 months, cumulative survival rate was 94.9%. Chi square test was performed to find statistical significance under each factor (table 7).

- Survival rate according to patient factors

According to gender, there were 49 implant failures in 750 male patients and the survival rate was 93.5 %. There were 9 implant failures in 385 female patients and the survival rate was 97.7%. Male patients exhibited lower implant survival rate than female with statistical significance ($p<0.05$). According to ages, patient population of 50 to 59 years had 28 failures among 438 patients and showed lowest survival rate of 93.6%. However, age did not show statistical significance ($p<0.05$). According to the number of patients, 43 male patients and 9 female patients had implant failure. Six male patients in age group of 50s had 2 implant failures each.

- Survival rate according to implant factors

Implant location was divided into 4 areas (maxillary 1st molar, 2nd molar and mandibular 1st molar and 2nd molar) and each area had 22, 16, 10 and 10 implant failures respectively. The survival rates of each location were 92.3%, 94.9%, 95.4% and 96.9% respectively. Even though maxillary 1st molar area showed lowest survival rate, there was no statistical significance in implant location. However, when comparing maxilla versus mandible, maxilla showed lower survival rate of 93.6% while mandible showed statistically higher survival rate of 96.3% ($p<0.05$). When comparing grafted versus non-grafted natural sinus, Rescue implant survival rates differed with statistical significance. It showed 91.0% survival rate in grafted sinus area while non-grafted sinus showed statistically higher survival rate of 95.7% ($p<0.05$).

Survival rates according to different sizes of implants did not show statistical significance. 8mm diameter implant showed lowest survival rate of 91.6% among different diameters of implant. And 10mm length implant also showed lowest survival rate of 94.3% among different implant lengths. However, survival rates according to each diameter or length did not show statistically significant differences.

Survival rates of Rescue implants into fresh extraction socket versus healed socket showed statistically significant difference. It was 92.8% in fresh extraction socket and 95.9% in healed socket and Rescue implant placement into fresh extraction socket showed statistically lower survival rate ($p<0.05$). According to surgical methods, single stage approach had 93.5% and two stage approach showed statistically significant higher survival rate of 96.2% ($p<0.05$).

Single implant restoration versus multiple implants splinted restoration also showed statistically significant difference in survival rates. Single implant restoration showed 96.3%, while multiple implants splinted restoration showed 98.4% of higher survival rate.

Chi square test showed statistically significant factors which were genders, location (maxilla versus mandible), grafted versus natural sinuses, extraction socket versus healed socket, surgical method (single versus two stage approach) and single implant restoration versus multiple implant splinted restoration.

Cox regression model was executed and following 3 factors showed statistically significance (table 8).

Table 7. Survival Rate of Implants According to the Variables.

		n	failed(%)	survival(%)	*p* value
Sex	Male	750	49(6.5)	701(93.5)	0.002
	Female	385	9(2.3)	376(97.7)	
Age	20-29	32	1(3.1)	31(96.9)	0.810
	30-39	122	5(4.1)	117(95.9)	
	40-49	327	14(4.3)	313(95.7)	
	50-59	438	28(6.4)	410(93.6)	
	60-69	164	8(4.9)	156(95.1)	
	70-79	43	2(4.7)	41(95.3)	
	80-89	9	0(0)	9(100)	
Location	Maxilla	595	38(6.4)	557(93.6)	**0.043**
	Mandible	540	20(3.7)	520(96.3)	
	upper 1st molar	284	22(7.7)	262(92.3)	0.076
	upper 2nd molar	311	16(5.1)	295(94.9)	
	lower 1st molar	217	10(4.6)	207(95.4)	
	lower 2nd molar	323	10(3.1)	313(96.9)	
Sinus (Maxilla)	Sinus graft	268	24(9.0)	243(91.0)	**0.027**
	Non-sinus graft	327	14(4.3)	314(95.7)	
Implant diameter	6.0mm	161	6(3.7)	155(96.3)	0.300
	6.5mm	251	12(4.8)	239(95.2)	
	7.0mm	592	29(4.9)	563(95.1)	
	8.0mm	131	11(8.4)	120(91.6)	
Implant length	5.0mm	31	1(3.2)	30(96.8)	0.878
	6.0mm	50	2(4.0)	48(96.0)	
	7.0mm	243	10(4.1)	233(95.9)	
	8.5mm	460	25(5.4)	435(94.6)	
	10.0mm	351	20(5.7)	331(94.3)	
Placement time	Immediate	360	26(7.2)	334(92.8)	**0.030**
	Delayed	775	32(4.1)	743(95.9)	
Surgery stage	1 Stage	554	36(6.5)	518(93.5)	**0.043**
	2 Stage	581	22(3.8)	559(96.2)	
Hexagonal connection type	external	868	48(5.5)	820(94.5)	0.271
	internal	267	10(3.7)	257(96.3)	
Prosthesis	multiple	728	12(1.6)	716(98.4)	**0.037**
	Single	375	14(3.7)	361(96.3)	

Table 8. Cox Regression Model

	P value	Odds ratio (Exp(B))	95% CI for Exp(B)	
			Lower	Upper
Gender	0.035	3.772	1.100	12.941
Sinus	0.001	4.569	1.795	11.630
Prosth	0.001	4.568	1.888	11.051

Table 9. Significant factors according to locations. (Each Location)

				n	failed(%)	survived%)	*p* value
Maxiila	**1st molar**	Prosthesis	multiple	201	6(3.0)	195(97.0)	0.000
			single	72	5(6.9)	67(93.1)	
		Implant diameter	6.0mm	42	2(4.8)	4(95.2)	0.013
			6.5mm	60	7(11.7)	53(88.3)	
			7.0mm	153	7(4.6)	146(95.4)	
			8.0mm	29	6(20.7)	23(79.3)	
	2nd molar	Prosthesis	multiple	230	5(11.8)	225(97.8)	0.000
			single	76	6(7.9)	70(921.1)	
		Gender	male	216	15(6.9)	201(93.1)	0.028
			female	95	1(1.1)	94(98.9)	
Mandible	**1st molar**	Prosthesis	multiple	132	1(0.8)	131(99.2)	0.000
			single	78	2(2.6)	76(97.4)	
	2nd molar	Prosthesis	multiple	165	0(0.0)	165(100.0)	0.000
			single	149	1(0.7)	148(99.3)	
		Gender	male	198	10(5.1)	188(94.9)	0.008
			female	125	0(0.0)	125(100.0)	

Patient's gender showed significant influence in implant survival and male showed 3.8 times higher failure rate than female. In maxilla, history of sinus graft procedure had more impact than implant splinting. Grafted sinus showed 4.8 times more failure rate than non-grafted sinus. Implant splinted prostheses also had significant influence. Single standing implant restorations showed 4.6 times higher failure rate than multiple implants splinted together. In all molar regions of maxilla and mandible, Chi square test showed that implants splinting positively affect survival rate with statistical significance. In maxillary 1st molar area, implant diameter significantly affected its survival rate and in 2nd molar areas of both the maxilla and mandible, their survival rates were affected by gender.

- Type and timing of failure

In this study, most of the failed implants had been previously restored with crown and were removed within 1 year of function (53 implants in 58 total failures). Among those, 32 implants failed before the delivery of restoration (pre-prosthetic failure). Twenty one implants were restored with crowns and failed within 1 year (post prosthetic failure). 5 implants failed between loading period of 1 and 2 years. There were no failed implants after 3 years of loading. Pre-prosthetic failures of 32 implants were regarded as failure of osseointegration and they were removed as describe. Whenever rapid resorption of peri-implant bone was evident in radiographs, they were regarded as over-heating of bone and implants were removed (1 implant).

In two stage surgical approaches, when the implants were mobile during second stage surgery, they were removed. In single stage surgical approaches, when the implants were mobile during impression making, they were regarded as failed and were removed (4 implants).

When the infectious process around the implant was not controllable, it was removed, too (1 implant). Post-prosthetic failures (26 implants) were regarded as disintegration of fixture and bone.

Gradual bone destruction around the fixtures (3 implants), mobility of fixtures (5 implants), pain upon chewing or upon tapping (5 implants) were all regarded as failures and those implants were removed. In this study, sensory nerve disturbance or fracture of fixtures were not observed (Table 9, figure 1).

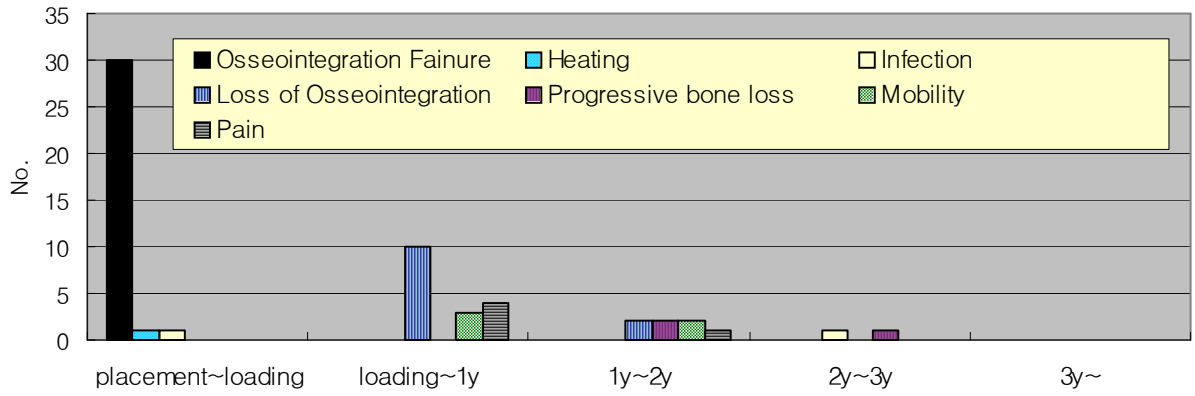

Fig 1. Detail of Complication

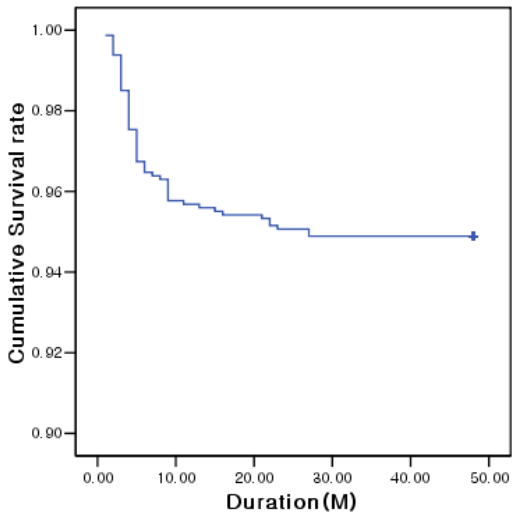

Fig 2. Kaplan-Meier survival analysis

- Survival rate analysis

Total of 1135 wider implants were followed for up to 42 months and failures were observed up to 27 months. No failures were found afterwards. An average of 5 months for osseointegration was given, and then restorations were done. Up to this period, the cumulative survival rate with 32 failures was 97.2%. From the delivery of restoration and 1 year after the placement of implant, 17 failures occurred and the cumulative survival rate was 95.7%. 7 failures between 1st and 2nd year after implant placement were found and the survival rate was 95.1%. Between 2nd and 3rd year after implant placements, 2 failures occurred and the survival rate was 94.9%. After 3 years, there were no failures and the cumulative survival rate remained the same (table 10, figure 2).

Table 10. Life table method

Time	Implant at start of interval	No. of failed implant	Survived implant	Survival rate in the interval	Cumulative survival rate (%)
Placement to loading	1135	32	1103	97.2	97.2
Loading to 1 year	1103	17	1086	98.5	95.7
1 to 2 year	1086	7	1079	99.4	95.1
2 to 3 year	1079	2	1077	99.8	94.9
3 year -	1077	0	1077	100.0	94.9

Discussion

Since late 1980s, wide diameter implants were used in order to improve prognosis in poor bone quality[4]. In 1993, Langer et al[5] reported the use 5mm wide diameter (Branemark, Sweden) implants in wide ridge of bone when the bone heights were compromised above mandibular canals or below maxillary sinuses. They were also used on the sites of previous implant failures and in poor quality bone where 3.75mm standard diameter implants could not achieve adequate primary stability. Lazzarra et al[22] suggested utilization of wide implants into fresh extraction sockets in order to reduce the bone defect between the sockets and implants. Martinez et al[16] pointed out that wide diameter implants were indicated only where there was at least 8mm width of bone bucco-lingually and 8 to 11mm of bone mesio-distally.

However, long-term study results on wide diameter implants are scarce and they report contradicting results. Langer et al[5] reported 75 to 87% success rates on 5.0 and 5.5mm diameter implants in their 1.5 year follow-up study. Renouard et al[13] reported a 91.8% success rate in their 5mm diameter implants with follow-up of 1 year and they also reported that 24% of their patients had lost crestal bone up to the 2nd thread in their radiographic exams. Ivanoff et al[23], in their 3 to 5 year follow-up studies of 5mm diameter implants reported a survival rate of 82%. They pointed out that their compromised results were due to the fact that 45% of wide implants were used as 'Rescue' fixtures to replace failed implants in compromised bone quantity and quality. They also indicated that inadequate implant design in poor bone quality and lack of surgical experience in wide implants contributed to the compromised results. They suggested the development and adoption of new surgical techniques including drilling sequences in order to improve the success rates.

Several studies reported higher failure rates and they indicated that the majority of them were pre-prosthetic failures[11,12,23]. Ivanoff[23] pointed out that wide implant failures were from failure of osseointegration and they were removed either at the second stage surgery or within 2 years of loading.

While there are reports of compromised success rates, there are several studies reporting comparable success rates as standard diameter implants[4,7,8,14,15,24]. Graves et al[15], in their 2 year follow-up study of 5 and 6mm diameter implants, reported success rates of 95.9%. Davarpanah et al[24], in their 2 year follow-up of 5mm diameter (Nobel Biocare, Sweden), reported a 96% success rate. Krennmair and Waldenberger[7] reported 98.3% survival rate in their 12 to 113 month follow up study of 6mm diameter implants. Anner et al[8], in their 6mm diameter implant study with 1 to 54 months follow-up, reported 100% survival rate. These studies suggested that adapted surgical protocol for poor bone quality/quantity, use of roughened surface implants and proper diagnosis led to comparably higher success rates as standard diameter implants. In our study, the cumulative survival rate, in up to 42 months follow-up, was 94.9% with 58 failed implants among the total number of 1,135 wide implants.

Male patients showed lower implant survival rate (93.5%) and it agreed with findings from Higuchi et al[25], whose study suggested that male exerted higher masticatory forces, which was not a favorable factor to implant survival. According to age group, patients in their 50s showed lowest implant survival rate (93.5%). In male populations, patients in their 50s showed lowest implant survival rate of 91.5%. In female populations, patients in their 70s showed the lowest implant survival rate of 94.5%. Six male patients in their 50s showed 2 implant failures and the rest had single failures. While not investigated, it was probable that male smoking habit contributed to their higher failure rate.

According to location, the maxilla exhibited a statistically significant lower survival rate of 93.6% while the mandible showed a higher rate of 96.3%. Poorer bone quality of the maxilla and sinus grafting procedures in compromised maxillary bone height were suspected to lead lower survival rate[7].

According to grafted versus non-grafted sinuses, grafted sinuses showed statistically significant lower survival rate of 91.0% while non-grafted sinus was 95.7% and the mandible was 96.3%. This result agreed with the findings of Hurzeler et al[26] whose study indicated that implants into grafted sinus bone lacked the proper amount of natural bone for initial stability and grafting material in sinuses were not able to prevent micro-movement of implants and provide mechanical stability.

According to implant diameter, 8mm implants showed lowest survival rate of 91.6%. Even though it was not statistically significant, as diameter widened, so was failure rate and it was most apparent in 8mm diameter implants. Eckert et al [11] indicated that as diameter increased, so was waste of bone tissue during osteotomy preparation and the wide osteotomy frequently invaded minimal space requirements of 1mm bucco-lingually, 3mm between implants and 1.5 to 2mm from natural

dentition. Stellingsma et al[27] stated that if minimal amount of bone existed with poor blood supply, there would be compromised osteogenesis which would lead to poor osseointegration.

According to fixture lengths, the longest implants of 10mm showed the lowest survival rate of 94.3%. However, it did not show statistical significance. Misch[21] reported that after achieving initial stability with minimal length implants, diameter played a more important role in success rate than length because stress is mostly distributed at the crestal level of the fixture, when in function. Also, in this study, the length was found to be less important factor than the diameter.

According to surgical methods, single stage approach showed lower survival rate of 93.5% with statistical significance. Eckert et al[11] stated that larger diameters were subject to more loading through the mucosa. Also, Gentile et al[28] reported that two the stage approach was more favorable for osseointegration because the healing abutment connection after surgery might introduce harmful loading to the fixture.

Splinting an implant with an adjacent implant showed higher survival rate (98.8%) than a single standing implant restoration (96.3%) with statistical significance. Bidez[29] reported that stress transmission to implant-bone interface increased in single standing implant restoration while in multiple splinted implants, restoration was subject to significantly less stress loading to the bone. In addition, this study limited implant length to less than 10mm and our results confirms the finding of Gentile[28] that shorter implants showed better result if splinted with longer implants.

After execution of Chi square test at each location, splinted implants restoration showed higher survival rate with statistical significance. In the maxillary 1st molar area, implant diameter of 8mm showed statistically significant lower survival rate of 79.3%. Possible explanation to this could be as follows. If residual bone height became compromised because of sinus pneumatization or periodontal bone destruction, increase in bone cutting from larger osteotomy preparation led to decrease in mechanical stability of implant and also led to poor blood supply.

Lastly, in the maxillary 2nd molar area, males showed lower survival rates than females with statistical significance. Since 2nd molar receives more masticatory force and unlike 1st molar which has adjacent teeth in both mesial and distal, 2nd molars are subject to heavier loading in male because of stronger masticatory muscles. Bone in maxillary 2nd molar area is generally poor in density and it also has less cortical bone with more spongeous bone. Therefore, implants had less mechanical stability with bone and compromised blood supply.

There was no failure due to neuro-sensory disturbance or implant fracture. Since this study included shorter implants of less than 10mm, it enabled us to place implants further away from the mandibular canals. As Davarpanah[4] reported, there was no implant failure due to fracture of the implant itself because the increase in diameter led to an increase in fracture resistance.

According to timing of failures, early failure rate (before loading with prosthesis) was 57.1% (32 implants) and late failure rate (after loading with prosthesis) was 42.9% (26 implants). Prosthetic loading up to 1 year showed a 36.2% (21 implants) failure rate and a loading period between 2 to 3 years showed a failure rate of 8.6% (5 implants). Therefore, most of failures occurred within 1 year of loading. Renouard et al[13] and also Ivanoff et al[23] reported similar results. According to Higuchi et al[25], implant failure occurred because of improper surgical technique, poor initial stability, inadvertent loading prior to completion of osseointegration and application of higher torque in connecting the healing abutment.

In this study, larger diameter implants showed similar survival rates as Choi et al[18] showed in standard diameter implants. Renouard et al[14], in their study suggested that if several diagnostic and surgical protocols improved, there would be no co-relation between survival rate and width of implants. In this study, we concluded that if accurate diagnosis of bone quality and quantity before surgery, proper surgical technique to achieve initial primary stability and proper prosthetic options such as implant splinting were done, favorable clinical results could be achieved with wider implants of 6 to 8mm in diameters.

Rather than applying more strict criteria for implant success, any implants in function were regarded as survived in this study. Also, the follow-up period was relatively short. Therefore, in order for further in-depth investigation on success rates of wider implants, we need a prospective study with longer follow-up periods.

Conclusion

1135 wider implants placed in the molar area of 650 patients were studied according to age, gender, location, diameter and length, extraction socket versus healed bone, single versus two stage surgical approach and single versus splinted prosth-

esis.
The following results were found after investigation of survival rates of each criterion.

1. Up to 42 months of follow-up, implant failure rate was 8.0% in patient population and 5.1% in total implant number. Cumulative survival rate was 94.9%.
2. Upon execution of chi square tests, gender, implant location, maxilla versus mandible, grafted sinus versus natural sinus, extraction socket versus healed bone site, single stage versus two stage surgical approaches and single standing versus multiple implants splinted restorations were the statistically significant factors ($p<0.05$) to implant survival rate.
3. Upon execution of Cox regression model, gender, sinus graft, and splinting of implants were the significant factors to survival rates of implants. Males showed poorer prognosis than females (3.8 times), grafted sinus showed poorer prognosis than natural sinus (4.6 times) and single standing restoration showed poorer prognosis than multiple implant splinted restoration (4.6 times).
4. Upon execution of chi-square test according to location, multiple implants splinted restoration showed higher survival rates in all locations with statistical significance. Maxillary 1st molar area showed the lowest survival rate with 8mm diameter implants. 2nd molar implants of both maxilla and mandible showed lower survival rate in male patients ($p<0.05$).
5. 32 implants from total of 52 implant failures were removed before loading with prosthesis and the cumulative survival rate up to implant loading was 97.2%. Up to 1 year of loading, the cumulative survival rate was 95.3%. No implant failure was seen after 27 months and it showed stable cumulative survival rate afterwards.
6. There was no implant failure from neurosensory disturbance or fracture of implants.

This study suggests that if careful selection of patients were done and proper surgical protocols employed, the use of wider implants (6 to 8mm) show comparably and equally favorable results as standard diameter implants.

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