Comparison of implant component fractures in external and internal type: A 12-year retrospective study

Yuseung Yi[1], Jai-Young Koak[1], Seong-Kyun Kim[1], Shin-Jae Lee[2], Seong-Joo Heo[1]*

[1]Department of Prosthodontics & Dental Research Institute, School of Dentistry, Seoul National University, Seoul, Republic of Korea
[2]Department of Orthodontics, School of Dentistry, Seoul National University, Seoul, Republic of Korea

PURPOSE. The aim of this study was to compare the fracture of implant component behavior of external and internal type of implants to suggest directions for successful implant treatment. **MATERIALS AND METHODS.** Data were collected from the clinical records of all patients who received WARANTEC implants at Seoul National University Dental Hospital from February 2002 to January 2014 for 12 years. Total number of implants was 1,289 and an average of 3.2 implants was installed per patient. Information about abutment connection type, implant locations, platform sizes was collected with presence of implant component fractures and their managements. SPSS statistics software (version 24.0, IBM) was used for the statistical analysis. **RESULTS.** Overall fracture was significantly more frequent in internal type. The most frequently fractured component was abutment in internal type implants, and screw fracture occurred most frequently in external type. Analyzing by fractured components, screw fracture was the most frequent in the maxillary anterior region and the most abutment fracture occurred in the maxillary posterior region and screw fractures occurred more frequently in NP (narrow platform) and abutment fractures occurred more frequently in RP (regular platform). **CONCLUSION.** In external type, screw fracture occurred most frequently, especially in the maxillary anterior region, and in internal type, abutment fracture occurred frequently in the posterior region. placement of an external type implant rather than an internal type is recommended for the posterior region where abutment fractures frequently occur. ***[J Adv Prosthodont 2018;10:155-62]***

KEYWORDS: Implant fracture; Screw fracture; Abutment fracture; Fixture fracture

INTRODUCTION

Endosseous implants are reliable choice of treatment for the replacement of missing natural teeth. Although the overall success rate of implant is relatively high, between 95 - 98%,[1] they often encounter complications such as peri-implantitis and other technical problems. According to several previous studies, the most common cause of implant failure is peri-implantitis and technical complications are not uncommon.[2-4] Technical problems of implant-supported restorations can be classified into two groups: those relating to the prosthesis, and those relating to the implant components.[5-6] Technical problems relating to the prosthesis are such as veneering material or framework fractures and technical problems relating to the implants components include screw loosening or screw fractures, abutment fracture and implant fixture fractures. If the problem is caused by the implant prosthesis itself, the problem can be overcome by refabricating the prosthesis. However, in the case of problems associated with implant components, various solutions must be sought, simply to replace the implant components or, in some cases, remove the implants, which makes it diffi-

Corresponding author:
Seong-Joo Heo
Department of Prosthodontics, School of Dentistry, Seoul National University, 101, Daehak-ro, Jongno-gu, Seoul 03080, Republic of Korea
Tel. +82220722661: e-mail, heosj@snu.ac.kr
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cult to predict the solution. Adell *et al.*[7] reported a 3.5% implant fixture fracture in a 15-year study of Brånemark implant in 1981. Naert *et al.*[8] reported a 0.53% implant fracture, 8.9% abutment screw fracture, and 1.2% occlusal screw fracture in a case study of implant supporting complete fixed prosthesis with Brånemark implant in 1992. As regards the fracture of implant, Rangert *et al.*[9] said it was associated with bruxism or strong occlusal force, and it occurred more frequently in an single or double implant prosthesis of the posterior region. In a retrospective study of implant complications in 1997, Tolman and Laney reported[10] that screw fractures occurred in 87 of 1,250 implants (7.0%). Although there have been several studies on fracture of the implant components, most studies report only failure of the osseointegration as failure of the implant and it is overlooked that implant failure can be caused by implant component fracture. Clinically, in the case of implant abutment fracture or screw fracture, it is recommended to remake the prosthesis after removing the fractured remnant. However, it is difficult to remove the fragments and eventually the implants must be removed, leading to implant failure.

The purpose of this study was to predict the prognosis of implants and to suggest directions for successful implant treatment by analyzing the factors affecting the fracture of implant components including abutment connection type, implant location and implant platform size.

MATERIALS AND METHODS

Data were collected from the clinical records of all patients who received one or more WARANTEC implants at Seoul National University Dental Hospital from February 2002 to January 2014 for 12 years and the following cases were excluded: i) implants failed in osseointegration, ii) implant placement after jaw resection and reconstruction, iii) the opposite arch was complete denture, iv) implant assisted over denture, v) insufficient clinical chart recording, vi) patients who have not visited since 2012. Data collection included 406 patients (205 males, 201 females), ranging in age from 21 to 94 years (mean 64.6 years, SD 11.5). Total number of implants was 1,289 and an average of 3.2 implants was installed per patient. Information about abutment connection type (internal or external), implant locations, platform sizes was collected with presence of implant component fractures and their managements (Table 1). The information about implant component fractures was divided into three types: screw fractures, abutment fractures, and fixture fractures. The management of fractures was classified as screw replacement, prosthesis refabrication, and fixture removal.

SPSS statistics software (version 24.0, IBM, New York, NY, USA) was used for the statistical analysis. The Pearson chi-square test and Fisher's exact test ($P = .05$) were used to evaluate the association between implant characteristics and implant components fracture.

Table 1. Distribution of implants according to the location and platform size

Number of implants / Location			Maxillary Anterior	Maxillary Posterior	Mandibular Anterior	Mandibular Posterior	Total (%)
External type	Platform size	NP	42	32	22	11	107 (13.4)
		RP	75	295	18	243	631 (79.0)
		WP	2	30	0	29	61 (7.6)
		Total (%)	119 (14.9)	357 (44.7)	40 (5.0)	283 (35.4)	799 (100)
Internal type	Platform size	NP	6	9	1	6	22 (4.5)
		RP	14	253	9	152	428 (87.3)
		WP	0	22	0	18	40 (8.2)
		Total (%)	20 (4.1)	284 (58.0)	10 (2.0)	176 (35.9)	490 (100)
TOTAL	Platform size	NP	48	41	23	17	129 (10.0)
		RP	89	548	27	395	1059 (82.2)
		WP	2	52	0	47	101 (7.8)
		Total (%)	139 (10.8)	641 (49.7)	50 (3.9)	459 (35.6)	1289 (100)

NP = Narrow Platform, RP = Regular platform, WP = Wide platform

RESULTS

A total of 1,289 implants were placed in 406 patients during investigation period. 799 implants had external type abutment connection (62.0%) and 490 implants were internal type abutment connection (38.0%). 139 implants were placed in the maxillary anterior region (10.8%), 641 implants in the maxillary posterior region (49.7%), 50 implants in the mandibular anterior region (3.9%), and 449 implants in the mandibular posterior region (35.6%). According to the platform size, 129 implants (10.0%) with narrow platform (NP), 1059 implants (82.2%) with regular platform (RP), and 101 implants (7.8%) with wide platform (WP) were placed (Table 1, Fig. 1).

Of the total 1,289 implants, component fractures occurred in 72 implants (5.6%). In internal type implants, 53 components fractures occurred (10.8%): 8 screw fractures (1.6%), 40 abutment fractures (8.2%), and 5 fixture fracture (1.0%), and in external type implants, 19 components fractures occurred (2.4%): 16 screw fractures (2.0%), 1 abutment fracture (0.1%), and 2 fixture fractures (0.3%) (Table 2).

Overall fracture was significantly more frequent in internal type ($P < .001$). The most frequently fractured component was abutment in internal type implants (8.2%), and screw fracture occurred most frequently (2.0%) in external type (Fig. 2).

The implants were most placed in the maxillary posterior region (49.7%), followed by the mandibular posterior region (35.6%) (Table 1). Table 3 shows the most frequent location which implant component fractures occurred was the maxillary posterior region in internal type (10.8%), and maxillary anterior region in external type (5.9%).

Analyzing by fractured components, screw fracture was the most frequent in the maxillary anterior region (5.0%) and the most abutment fracture occurred in the maxillary posterior region (4.1%) significantly ($P = .013 < .050$) (Table 3, Fig. 3A).

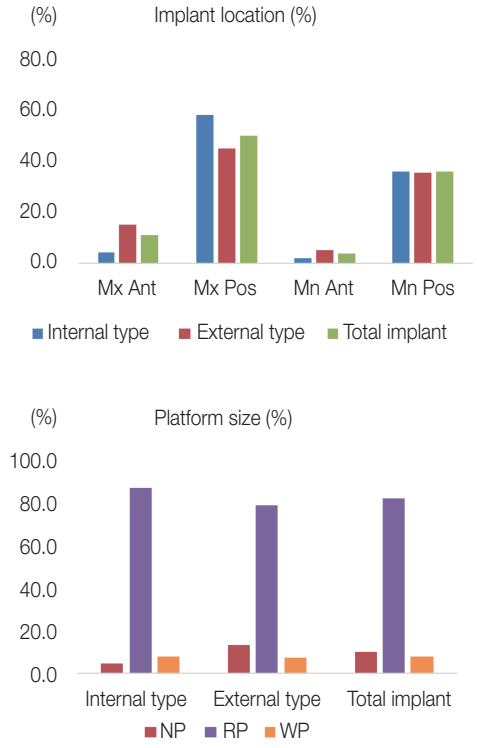

Fig. 1. Implant distribution according to the location and the platform sizes.

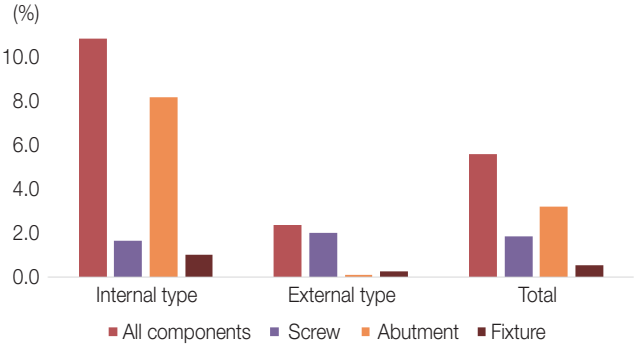

Fig. 2. Implant component fracture. Overall fracture was significantly more frequent in internal type. The most frequently fractured component was abutment in internal type implants, and screw fracture occurred most frequently in external type.

Table 2. Implant component fractures

	Internal type (%)	External type (%)	Total (%)
Total implants	490 (38.0)	799 (62.0)	1,289
Screw fracture	8 (1.6)	16 (2.0)	24 (1.9)
Abutment fracture	40 (8.2)[a]	1 (0.1)[b]	41 (3.2)
Fixture fracture	5 (1.0)	2 (0.3)	7 (0.5)
Total fracture	53 (10.8)[b]	19 (2.4)[c]	72 (5.6)

Different letters mean significant difference ($P < .05$)

There was significant relationship between platform size and fractures. In external type, the number of fractures of NP was larger than that in other platform sizes, and more fractures occurred in the RP than other platform sizes in internal type.

Analyzing by fractured components, screw fractures occurred more frequently in NP (narrow platform) and abutment fractures occurred more frequently in RP (regular platform) (Table 4, Fig. 3B).

Table 3. Fractures depending on implant location

By abutment connection type			
	Internal type (%)	External type (%)	Total (%)
Maxillary anterior	0 (0.0)	7 (5.9)	7 (5.0)
Maxillary posterior	31 (10.9)	11 (3.1)	42 (6.6)
Mandibular anterior	0 (0.0)	0 (0.0)	0 (0.0)
Mandibular posterior	22 (12.5)	1 (0.4)	23 (5.0)
Total fracture	53 (10.8)	19 (2.4)	72 (5.6)

By fractured components				
	Screw (%)	Abutment (%)	Fixture (%)	Total (%)
Maxillary anterior	7 (5.0)	0 (0.0)	0 (0.0)	7 (5.0)
Maxillary posterior	11 (1.7)	26 (4.1)	5 (0.8)	42 (6.6)
Mandibular anterior	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Mandibular posterior	6 (1.3)	15 (3.3)	2 (0.4)	23 (5.0)
Total fracture	24 (1.9)	41 (3.3)	7 (0.6)	72 (5.6)

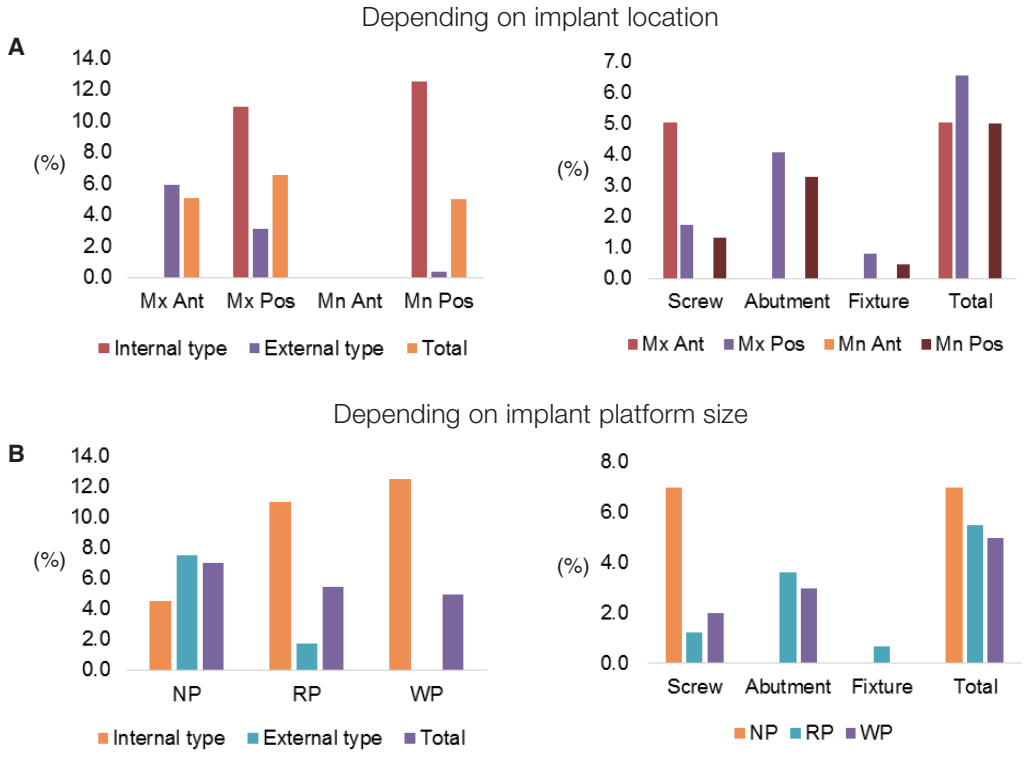

Fig. 3. Implant component fracture. (A) Screw fracture was the most frequent in the maxillary anterior region and the most abutment fracture occurred in the maxillary posterior region significantly. (B) In external type, the number of fractures of NP was larger than that in other platform sizes, and more fractures occurred in the RP than other platform sizes in internal type. Screw fractures occurred more frequently in NP and abutment fractures occurred more frequently in RP. Mx = Maxillary, Ant = Anterior, Mn = Mandibular, Pos = Posterior, NP = Narrow platform, RP = Regular platform, WP = Wide platform.

Table 4. Fractures depending on implant platform size

By abutment connection type			
	Internal type (%)	External type (%)	Total (%)
NP	1 (4.5)	8 (7.5)	9 (7.0)
RP	47 (11.0)	11 (1.7)	58 (5.5)
WP	5 (12.5)	0 (0.0)	5 (5.0)
Total fracture	53 (10.8)	19 (2.4)	72 (5.6)

By fractured components				
	Screw (%)	Abutment (%)	Fixture (%)	Total (%)
NP	9 (7.0)	0 (0.0)	0 (0.0)	9 (7.0)
RP	13 (1.2)	38 (3.6)	7 (0.7)	58 (5.5)
WP	2 (2.0)	3 (3.0)	0 (0.0)	5 (5.0)
Total fracture	24 (1.9)	41 (3.2)	7 (5.2)	72 (5.6)

NP = Narrow Platform, RP = Regular Platform, WP = Wide Platform

DISCUSSION

The number of implants installed for 12 years from 2002 to 2014 was greater in the external type (62.0%) than in the internal type (38.0%). Depending on implant locations, implants were mostly placed at the maxillary posterior region (49.7%), followed by 35.6% at the mandibular posterior region, 10.8% at the maxillary anterior region and 3.9% at the mandibular anterior region. Depending on implant Platform sizes, RP (Regular platform) was the most placed at all locations with 82.2%, NP (Narrow Platform) was placed in the anterior region with 10.0%, WP (Wide Platform) was placed in the posterior region mostly with 7.8% (Table 1, Fig. 1).

Of the total 1,289 implants, component fractures occurred in 72 implants (5.6%). In internal type implants, 53 components fractures occurred (10.8 %): 8 screw fractures (1.6%), 40 abutment fractures (8.2%), and 5 fixture fracture (1.0%), and in external type implants, 19 components fractures occurred (2.4%): 16 screw fractures (2.0%), 1 abutment fracture (0.1%), and 2 fixture fractures (0.3%). Table 5 shows the relationship between various factors and implant component fractures.

Comparing the overall implant component fracture of the internal and external types, the fracture rate in internal type was significantly higher than in external type ($P < .001$). By implant components, there were no significant difference between internal and external types in screw or fixture fractures, only in abutment fracture, internal type (8.2%) was significantly higher than external type (0.1%) ($P < .001$).

Depending on the implant location, in internal types, there was no significant relationship between the implant location and each component fracture rates, however, in external types, there was a significant difference in total

Table 5. Implant component fractures

		Screw	Abutment	Fixture	Total
External type		2.00%	0.10%	0.30%	2.40%
Internal type		1.60%	8.20%	1.00%	10.80%
P value		.402	< .001*	> .999	< .001*
Component fractures depending on implant location					
External type	Mx Ant	5.90%	0.00%	0.00%	5.90%
	Mx Pos	2.50%	0.00%	0.60%	3.10%
	Mn Ant	0.00%	0.00%	0.00%	0.00%
	Mn Pos	0.00%	0.40%	0.00%	0.40%
	*P*P value	.003*	.553	.683	.007*
Internal type	Mx Ant	0.00%	0.00%	0.00%	0.00%
	Mx Pos	0.70%	9.20%	1.10%	10.90%
	Mn Ant	0.00%	0.00%	0.00%	0.00%
	Mn Pos	3.40%	8.00%	1.10%	12.50%
	P value	.186	.601	> .999	.327
Component fractures depending on implant platform size					
External type	NP	7.50%	0.00%	0.00%	7.50%
	RP	1.30%	0.20%	0.30%	1.70%
	WP	0.00%	0.00%	0.00%	0.00%
	P value	.001*	> .999	> .999	.003*
Internal type	NP	4.50%	0.00%	0.00%	4.50%
	RP	1.20%	8.60%	1.20%	11.00%
	WP	5.00%	7.50%	0.00%	12.50%
	P value	.092	.407	> .999	.662

*significant ($P < .05$).
Mx = Maxillary, Mn = Mandibular, Ant = Anterior, Pos = Posterior, NP = Narrow Platform, RP = Regular Platform, WP = Wide Platform

fracture rate ($P = .007 < .05$) and screw fracture ($P = .003 < .05$) in maxillary anterior region was significantly higher (5.8%).

Analyzing according to implant platform size, NP (Narrow platform) showed significantly higher total fracture rate ($P = .003 < .05$) and higher screw fracture rates ($P = .001 < .05$) in external type and there was no significant difference in internal type.

In most cases, screw loosening precedes screw fracture. Screw loosening is a relatively frequent complication and it occurs more frequently in external type than internal type, in screw-retained type than in cemented type, in lower arch than in upper arch, and in single tooth restoration than multiple restorations.[11,12]

In this retrospective study, screw fracture occurred in internal type 1.6% and external type 2.0%, but there was no significant difference according to connection type. There was a significant difference according to implant position and platform size. The most frequent location was in the maxillary anterior region (5.9%), and most of them occurred in NP (narrow platform) according to the platform size (7.5%). In other words, screw fracture occurs most frequently in maxillary anterior region with NP (narrow platform) in external type (Fig. 4A). According to previous

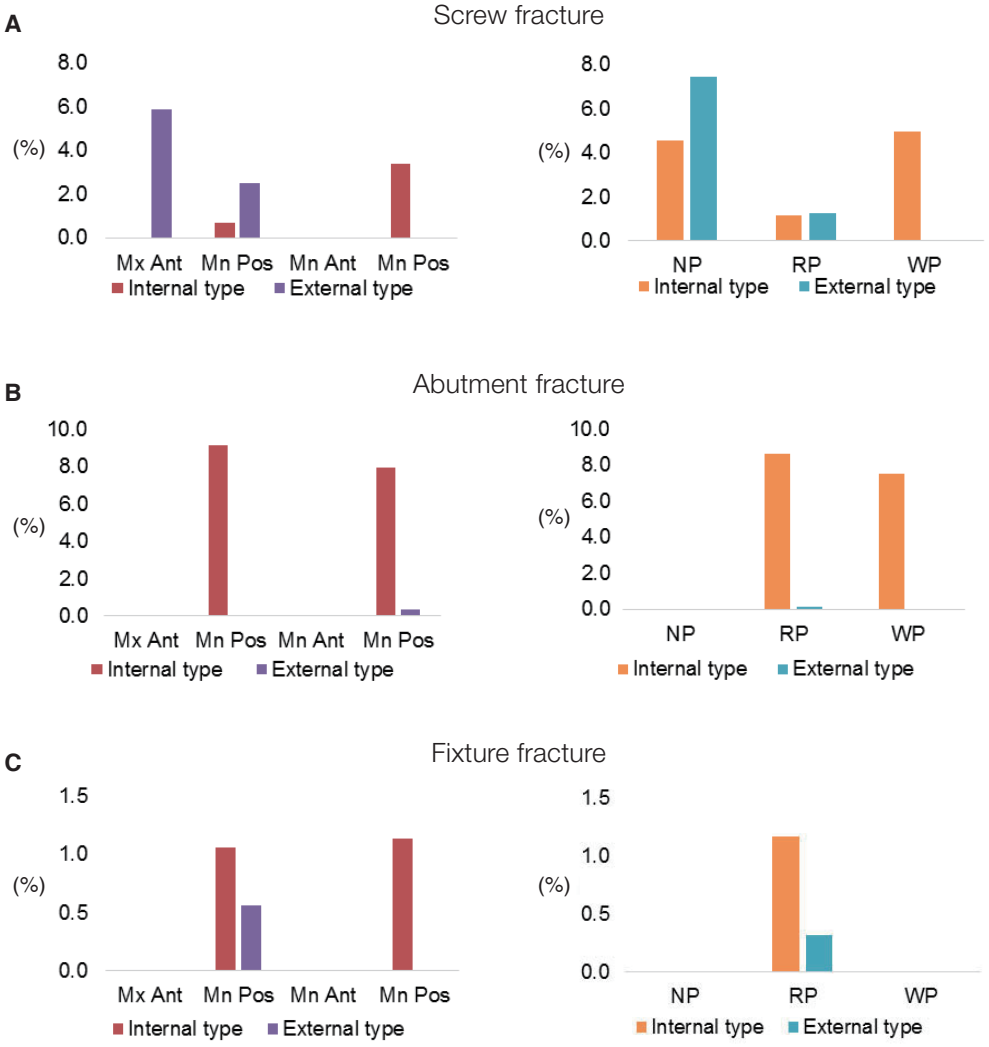

Fig. 4. Implant component fractures (By implant component). (A) Screw fracture occurred in internal type 1.6% and external type 2.0%, but there was no significant difference according to connection type. There was a significant difference according to implant position and platform size. The most frequent location was in the maxillary anterior region (5.9%), and most of them occurred in NP. (B) Abutment fracture occurred more frequently in internal type (8.2%) than in external type (0.1%). There was no significant difference in fracture rate according to the implant location, but all fractures occurred in posterior region. (C) Fixture fracture occurred 1.0% in internal type, and 0.3% in external type, there was no significant difference according to implant connection type or implant location, however, all fixture fractures occurred at the posterior region in RP. Mx = Maxillary, Mn = Mandibular, Ant = Anterior, Pos = Posterior, NP = Narrow Platform, RP = Regular Platform, WP = Wide Platform.

studies, screw fracture is caused by various factors such as excessive bite force, improper placement of implant, bone loss, inappropriate fit or design of prosthesis, accumulation of fatigue, defect in fabrication and type of implant.[13-16] In internal type, the retention of the implant superstructure is obtained by the friction between the implant abutment and the fixture inner surface and screw. However, in external type, the contact surface between the implant abutment and the fixture is smaller than in internal type structurally, and the retentive force of the superstructure is achieved only by screws. Therefore, when excessive lateral force or other factors are applied to the implant, the force is transmitted to the implant screw, and if the force exceeds the retention threshold of the screw, screw loosening will occur, or if it exceeds the fracture threshold, screw fracture will occur. During eccentric movement, the implants in maxillary anterior region are affected by the lateral force and the bending force transmitted to the implant screw also increases, eventually causes screw fracture. Since the fixation screw of NP (narrow platform) abutment has also narrow diameter, thus, the fracture resistance threshold is small and therefore susceptible to fracture when the factors are applied.

Although many researches about implant screw or fixture fracture have been conducted, there is little analysis of abutment fracture. In this study, abutment fracture occurred more frequently in internal type (8.2%) than in external type (0.1%). There was no significant difference in fracture rate according to the implant location, but all fractures occurred in posterior region. (Fig. 4B) What is remarkable is all abutment fractures occurred in single implant restoration in posterior region using gold cast UCLA type with internal hex abutment connection. This type of implant prosthesis is a superstructure of a unit, so that when the lateral force applies, the force concentrates on the implant abutment neck area, causing a bending moment, which causes fracture of the abutment neck.

Implant fixture fracture is classified as late failure and have been reported to be caused by various factors. When the bone resorption occurs due to peri-implantitis, the bending stress from the masticatory force increases and the stress concentrates at the end of the abutment screw and acts as a starting point of the fracture.[17,18]

As a result of this study, fixture fracture occurred 1.0% in internal type, and 0.3% in external type, there was no significant difference according to implant connection type or implant location, however, all fixture fractures occurred at the posterior region in RP (regular platform) (Fig. 4C). Rangert *et al.*[17] reported that 90% of implant fractures are located in the molar and premolar regions of the mouth, where chewing forces and lateral movements associated with cusp inclination generate undesirable forces. When a implant is subjected to a force, external and internal types exhibit different force distribution structurally. In external type, when an external force is applied, the stress is transferred to the screw, which is the most susceptible part, and the screw fracture occurs before the fixture is stressed beyond the fracture resistance, thereby preventing the fracture of the fixture. In internal type, however, the mechanical interface between the abutment and the fixture is present, so that when the external force is applied, the stress transmitted to the abutment is transmitted to the fixture and if the stress exceeds the fracture resistance, fixture fracture is caused.

Table 6. How to cope with fractures

	Fractured component		
	Screw	Abutment	Fixture
Internal type			
Fixture removal	1 (12.5%)	10 (25%)	5 (100%)
Prosthesis refabrication (retrieve)	3 (37.5%)	29 (72.5%)	0 (0.0%)
Screw replacement (retrieve)	4 (50.0%)	0 (0.0%)	0 (0.0%)
Maintain fracture status	0 (0.0%)	1* (2.5%)	0 (0.0%)
External type			
Fixture removal	0 (0.0%)	0 (0.0%)	2 (100%)
Prosthesis refabrication (retrieve)	0 (0.0%)	1 (100%)	0 (0.0%)
Screw replacement (retrieve)	15 (93.8%)	0 (0.0%)	0 (0.0%)
Maintain fractured status	1** (6.2%)	0 (0.0%)	0 (0.0%)

* Fractured abutment could not be removed, being used.
** Fractured screw could not be removed, using new screw cut.

Clinically, when implant component fractures occur, the most important thing is whether the problem can be solved easily. When fixture fractures occur, it is considered as an implant failure since it can no longer function as an implant restoration and must be removed. However, in the case of screw or abutment fractures, the problem can be solved more easily if the fractured fragment can be removed. In other words, obtaining retrievability is the most important point to solve the problem. How to cope with fractures during this retrospective study was summarized in Table 6.

Only 12.5% of the fractured screws were not removed in internal type, and 6.2% in external type, in the case of abutment fracture, the abutment fragment removal was impossible in 27.5% and fixture were removed.

CONCLUSION

In external type, screw fracture occurred most frequently, especially in the maxillary anterior region, and in internal type, abutment fracture occurred frequently in the posterior region. The screw fracture seems to be easier to solve than the abutment fracture. Therefore, placement of an external type implant rather than an internal type is recommended for the posterior region where abutment fractures frequently occur. If an internal type implant is inevitably installed in

the posterior region, the SCRP type prosthesis or multi-unit abutment should be used instead of the one-unit UCLA type implant prosthesis for external force distribution.

ORCID

Seong Joo Heo *https://orcid.org/0000-0003-0699-4141*

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