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Clinical study on screw loosening in dental implant prostheses: a 6-year retrospective study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2020;46:133-142)

Objectives: In this study, we determined the incidence and pattern of screw loosening in patients who received dental implants.

Materials and Methods: Patients who received implants between January 2008 and October 2013 and completed their prosthetic rehabilitation were evaluated for the incidence, frequency, and onset of screw loosening using dental charts and radiographs. The association between each factor and screw loosening was analyzed using the chi-square test and a multivariate analysis with binary logistic regression models ($P<0.05$).

Results: Total 1,928 implants were placed in 837 patients (448 males, 389 females), whose follow-up period after loading varied from 0.25 to 70 months (mean period, 31.5 months). Screw loosening occurred in 7.2% of implants. Most cases occurred less than six months after loading. Among those, 22.3% experienced recurrent screw loosening. Screw loosening was most common in the molar region (8.5%) and frequently associated with an implant diameter of ≥5 mm (14.2%). External implant–abutment connections (8.9%) and screw-retained implant prostheses (10.1%) showed higher incidence of problems than internal implant–abutment connections and cement-retained implants, respectively. Screw loosening was most common in implant prostheses with single crowns (14.0%).

Conclusion: Within the limits of the current study, we conclude that the incidence of screw loosening differs significantly according to the position of implant placement, the type of implant and manufacturer, implant diameter, the type of implant–abutment connection, the type of retention in the implant prosthesis, and the type of implant prosthesis.

Key words: Dental implants, Screw loosening, Regression analysis

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I. Introduction

According to Brånemark[1], since the concept of osseointegration was first introduced in dentistry, osseointegrated dental implants have been included in the treatment options for patients undergoing prosthodontic treatment. Dental implant treatment is suggested for edentulous patients. It has a high success rate, even after long periods of observation[2,3].

Recently, many studies have reported problems following implant treatment. Goodacre et al.[4] reported that potential complications of implant treatment include osseointegration failure, surgical complications, marginal bone loss, peri-implantitis, mechanical complications, and aesthetic, masticatory, and phonetic problems. Calderon et al.[5] stated that the most frequently observed problems after implant treatment were mechanical complications, including screw loosening, screw fractures, implant fractures, porcelain fractures, and retention loss of implant-retained overdentures.

Screw loosening is a commonly observed implant compli-

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cation[6-8]. Jemt et al.[6] found that screw loosening was the most common problem encountered during the first year in 107 single-implant restorations using the Brånemark system. For 5 years, Kreissl et al.[7] observed partially edentulous patients who had undergone implant treatment and reported screw loosening in 6.7% of cases. Cho et al.[8] observed 213 dental implant patients over a period of 3 to 7 years and reported that screw loosening occurred in 10.3% of single-implant restoration cases and 12.1% of multiple implant restorations.

The screw connects the implant to the abutment. When the screw is tightened, rotational force is applied to it, whereas tensile force develops as it is elongated. This tensile force gives rise to a clamping force that allows the implant–abutment connection to be maintained[9]. However, in the presence of a load greater than the clamping force or during a loss of preload, the screw can loosen[10]. When that happens, the abutment and implant become mobile, which can in turn affect the surrounding soft tissue and implant structure. Localized inflammation can occur, or a sinus tract can form. Furthermore, when the stress is concentrated, screw fractures, abutment fractures, or even implant fractures can occur[11-13].

In this study, we used a retrospective analysis to determine the incidence and pattern of screw loosening in patients who received implants and identify factors that can increase the success rate of prosthodontic treatment.

II. Materials and Methods

1. Patient selection

We retrospectively reviewed the dental charts and radiographs of patients who received dental implant treatment at the Wonkwang University Dental Hospital Implant Center between January 2008 and October 2013 and completed their prosthetic rehabilitation.

This study was conducted after approval from the Institutional Review Board of Wonkwang University Dental Hospital (IRB No. WKDIRB201408-02).

We excluded patients who were missing information from their dental charts, whose implants were placed before the observation period even if they completed their prosthetic rehabilitation within the period of the study, and who suffered an implant failure after prosthetic rehabilitation. We also excluded patients who changed to a different type of implant prosthesis because of implant failure, those who underwent additional implant placement, and those who had a change in the type of opposing tooth.

After those exclusions, we analyzed 1,928 implants placed in 837 patients (448 males and 389 females; age range, 19-93 years; mean age, 54.5 years). The post-loading follow-up period, i.e., the period from the time of implant placement to the end of December 2013, ranged from 0.25 to 70 months (mean period, 31.5 months).

2. Types of implant and manufacturers

Eight different types of implants were used from six manufacturers: ET (Dio, Busan, Korea), GSIII (Osstem, Seoul, Korea), TSIII (Osstem), USII (Osstem), Pitt-easy (Oraltronics, Bremen, Germany), Restore (Lifecore Biomedical, Chaska,

Table 1. Characteristics of the subjects and implants in this study

		No. of patients or implants (%)
Sex	Male	448 (53.5)
	Female	389 (46.5)
Age (yr)	≤39	104 (12.4)
	40-49	132 (15.8)
	50-59	319 (38.1)
	60-69	186 (22.2)
	≥70	96 (11.5)
Implants (manufacturer)	ET (Dio)	189 (9.8)
	GSIII (Osstem)	11 (0.6)
	TSIII (Osstem)	232 (12.0)
	USII (Osstem)	356 (18.5)
	Pitt-easy (Oraltronics)	94 (4.9)
	Restore (Lifecore Biomedical)	4 (0.2)
	Osseotite (Biomet 3I)	499 (25.9)
	Xive (Friadent)	543 (28.2)
Implant diameter (mm)	≤3.5	177 (9.2)
	3.75-4.1	1,009 (52.3)
	4.5-4.9	327 (17.0)
	≥5	415 (21.5)
Implant length (mm)	≤9.5	87 (4.5)
	10-11.5	1,269 (65.8)
	12-14	450 (23.3)
	≥15	122 (6.3)
Arch	Maxilla	949 (49.2)
	Mandible	979 (50.8)
Position	Anterior	332 (17.2)
	Premolar	423 (21.9)
	Molar	1,173 (60.8)
Implant–abutment connection type	Internal hex	923 (47.9)
	External hex	1,005 (52.1)
Type of retention	Cement	1,063 (55.1)
	Screw	865 (44.9)
Type of prosthesis	Implant retained overdenture	32 (1.7)
	Splinted crown	1,188 (61.6)
	Cantilever bridge	17 (0.9)
	Single crown	691 (35.8)
Opposing tooth	Denture	61 (3.2)
	Fixed prosthesis	380 (19.7)
	Implant-supported prosthesis	358 (18.6)
	Natural tooth	1,129 (58.6)

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MN, USA), Osseotite (Biomet 3I, Palm Beach Gardens, USA), and Xive (Friadent, Mannheim, Germany). All of those implants are root-form implants. The diameter of the implants ranged from 2.5-6 mm, and the length ranged from 7-18 mm.(Table 1)

3. Dental chart investigation

When two or more implants were used in one patient and screw loosening occurred in individual implants, they were included as separate incidents in all categories except the sex and age of the patient. Additionally, we investigated cases of screw fractures, including whether the screw fracture occurred after screw loosening.

The characteristics of the subjects and implants used in this study have been summarized in Table 1.

4. Statistical analysis

The association between each factor and screw loosening was analyzed using the chi-square test in the IBM SPSS Statistics (ver. 23.0; IBM, Armonk, NY, USA). Differences were considered significant when $P<0.05$.

A multivariate analysis was performed using binary logistic regression models to determine the predictive effect of the independent variables associated with screw loosening. The "enter" method, based on a level of significance of $P<0.10$, was used to incorporate variables into the models.

Table 2. Incidence of screw loosening and fracture

			No. of implants (%)
Screw loosening	Incidence	No	1,789 (92.8)
		Yes	139 (7.2)
	Frequency	Once	108 (77.7)
		Twice	20 (14.4)
		3 times or more	11 (7.9)
	Onset (months since loading)	<6	70 (50.4)
		6-12	29 (20.9)
		12-24	19 (13.7)
		≥24	21 (15.1)
Screw fracture	Incidence	No	1,926 (99.9)
		Yes	2 (0.1)
	Onset (months since loading)	<6	1 (50.0)
		≥6	1 (50.0)
	Screw fracture after screw loosening	No	1 (50.0)
		Yes	1 (50.0)

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III. Results

1. Screw loosening and screw fracture in patients who received implant treatment

Information about the incidence, frequency, and onset of screw loosening is provided in Table 2. Details about the incidence and onset of screw fractures and whether they occurred after screw loosening are also shown in Table 2.

2. Relationship between screw loosening and the age and sex of the patient

Although screw loosening occurred more frequently in males (11.4%) than females (8.0%), that difference was not statistically significant ($P>0.05$).

Furthermore, although screw loosening was more frequently observed in patients older than 70 years (13.5%) than in younger age groups, that association was also not statistically significant ($P>0.05$).(Table 3)

3. Relationship between screw loosening and the location of the implant

The incidence of screw loosening was similar between the

Table 3. Screw loosening by sex and age

		Screw loosening		χ^2	*P*-value
		No	Yes		
Sex	Male	397 (88.6)	51 (11.4)	2.747	0.097
	Female	358 (92.0)	31 (8.0)		
Age (yr)	≤39	94 (90.4)	10 (9.6)	1.884	0.757
	40-49	119 (90.2)	13 (9.8)		
	50-59	289 (90.6)	30 (9.4)		
	60-69	170 (91.4)	16 (8.6)		
	≥70	83 (86.5)	13 (13.5)		

Values are presented as number of patients (%).

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Table 4. Screw loosening according to arch and position

		Screw loosening		χ^2	*P*-value
		No	Yes		
Arch	Maxilla	878 (92.5)	71 (7.5)	0.207	0.649
	Mandible	911 (93.1)	68 (6.9)		
Position	Anterior	309 (93.1)	23 (6.9)	10.500	0.005*
	Premolar	407 (96.2)	16 (3.8)		
	Molar	1,073 (91.5)	100 (8.5)		

*$P<0.05$.

Values are presented as number of implants (%).

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maxillary (7.5%) and mandibular (6.9%) arches, without any statistically significant difference (P>0.05).

The position of the implant was classified as anterior, premolar, or molar. Screw loosening occurred most frequently in the molar region (8.5%), followed by the anterior (6.9%) and premolar regions (3.8%) (P<0.05).(Table 4)

4. Relationship between screw loosening and the type of implant and manufacturer

The Pitt-easy implants showed the highest frequency of screw loosening (17.0%), followed by the ET implants (13.8%) and the Osseotite implants (8.0%) (P<0.05).(Table 5)

5. Relationship between screw loosening and implant diameter

The diameters of the implants ranged from 2.5-6 mm. They varied by the type of implant and manufacturer, so we classified them into the following four groups: ≤3.5 mm, 3.75-4.1 mm, 4.5-4.9 mm, and ≥5 mm. Screw loosening was observed most frequently in implants with a diameter ≥5 mm (incidence, 14.2%) (P<0.05).(Table 5)

6. Relationship between screw loosening and implant length

The lengths of the implants ranged from 7-18 mm. The lengths also varied by the type of implant and manufacturer, so we classified them into the following four groups: ≤9.5 mm, 10-11.5 mm, 12-14 mm, and ≥15 mm. The incidence of screw loosening was highest in implants with a length of 10-11.5 mm (7.9%); however, that difference was not statistically significant (P>0.05).(Table 5)

7. Relationship between screw loosening and type of implant-abutment connection

Implant–abutment connections are divided into external and internal types. Screw loosening was more frequent in the external group (8.9%) than in the internal group (5.4%) (P<0.05).(Table 6)

Table 6. Screw loosening according to the implant–abutment connection type and implant prosthesis retention type

		Screw loosening		χ^2	P-value
		No	Yes		
Implant–abutment connection type	Internal hex	873 (94.6)	50 (5.4)	8.504	0.004*
	External hex	916 (91.1)	89 (8.9)		
Type of retention	Cement	1,011 (95.1)	52 (4.9)	19.026	0.000*
	Screw	778 (89.9)	87 (10.1)		

*P<0.05.
Values are presented as number of implants (%).
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Table 5. Screw loosening by the implants used in this study

		Screw loosening		χ^2	P-value
		No	Yes		
Implants (manufacturer)	ET (Dio)	163 (86.2)	26 (13.8)	38.912	0.000*
	GSIII (Osstem)	11 (100)	0 (0)		
	TSIII (Osstem)	225 (97.0)	7 (3.0)		
	USII (Osstem)	331 (93.0)	25 (7.0)		
	Pitt-easy (Oraltronics)	78 (83.0)	16 (17.0)		
	Restore (Lifecore Biomedical)	4 (100)	0 (0)		
	Osseotite (Biomet 3I)	459 (92.0)	40 (8.0)		
	Xive (Friadent)	518 (95.4)	25 (4.6)		
Implant diameter (mm)	≤3.5	169 (95.5)	8 (4.5)	39.409	0.000*
	3.75-4.1	952 (94.4)	57 (5.6)		
	4.5-4.9	312 (95.4)	15 (4.6)		
	≥5	356 (85.8)	59 (14.2)		
Implant length (mm)	≤9.5	83 (95.4)	4 (4.6)	2.791	0.425
	10-11.5	1,169 (92.1)	100 (7.9)		
	12-14	422 (93.8)	28 (6.2)		
	≥15	115 (94.3)	7 (5.7)		

*P<0.05.
Values are presented as number of implants (%).
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8. Relationship between screw loosening and the type of retention in the implant prosthesis

The retention used in the implant prosthesis is divided into screw-retained types and cement-retained types. Screw loosening was more common in screw-retained implants (10.1%) than in cement-retained ones (4.9%) (P<0.05).(Table 6)

9. Relationship between screw loosening and the type of implant prosthesis

Screw loosening was most common in single crowns (14.0%), followed by cantilever bridges (11.8%) and splinted crowns (3.4%) (P<0.05).(Table 7)

10. Relationship between screw loosening and the type of opposing tooth

Screw loosening was most frequently observed in cases with natural opposing teeth (7.9%); however, that relationship was not statistically significant (P>0.05).(Table 7)

11. Repeated screw loosening

The characteristics of the subjects and implants with more than one occurrence of screw loosening have been summarized in Table 8. Among the patients with more than one occurrence of screw loosening, 75.0% were males. Among the implant prostheses, 90.3% were single crowns. With respect to the type of opposing tooth, 77.4% had a natural tooth as the opposing tooth.

Table 8. Characteristics of the subjects and implants in this study with two or more incidents of screw loosening

		No. of patients or implants (%)
Sex	Male	18 (75.0)
	Female	6 (25.0)
Age (yr)	≤39	1 (4.2)
	40-49	5 (20.8)
	50-59	10 (41.7)
	60-69	6 (25.0)
	≥70	2 (8.3)
Implants (manufacturer)	ET (Dio)	10 (32.3)
	GSIII (Osstem)	0 (0)
	TSIII (Osstem)	0 (0)
	USII (Osstem)	7 (22.6)
	Pitt-easy (Oraltronics)	4 (12.9)
	Restore (Lifecore Biomedical)	0 (0)
	Osseotite (Biomet 3I)	8 (25.8)
	Xive (Friadent)	2 (6.5)
Implant diameter (mm)	≤3.5	0 (0)
	3.75-4.1	10 (32.3)
	4.5-4.9	2 (6.5)
	≥5	19 (61.3)
Implant length (mm)	≤9.5	0 (0)
	10-11.5	28 (90.3)
	12-14	3 (9.7)
	≥15	0 (0)
Arch	Maxilla	16 (51.6)
	Mandible	15 (48.4)
Position	Anterior	1 (3.2)
	Premolar	3 (9.7)
	Molar	27 (87.1)
Implant-abutment connection type	Internal hex	7 (22.6)
	External hex	24 (77.4)
Type of retention	Cement	6 (19.4)
	Screw	25 (80.6)
Type of prosthesis	Implant-retained overdenture	0 (0)
	Splinted crown	3 (9.7)
	Cantilever bridge	0 (0)
	Single crown	28 (90.3)
Opposing tooth	Denture	0 (0)
	Fixed prosthesis	3 (9.7)
	Implant-supported prosthesis	4 (12.9)
	Natural tooth	24 (77.4)

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Table 7. Screw loosening according to implant prosthesis type and opposing teeth

		Screw loosening		χ^2	P-value
		No	Yes		
Type of prosthesis	Implant-retained overdenture	32 (100)	0 (0)	77.392	0.000*
	Splinted crown	1,148 (96.6)	40 (3.4)		
	Cantilever bridge	15 (88.2)	2 (11.8)		
	Single crown	594 (86.0)	97 (14.0)		
Opposing tooth	Denture	61 (100)	0 (0.0)	6.325	0.097
	Fixed prosthesis	357 (93.9)	23 (6.1)		
	Implant-supported prosthesis	331 (92.5)	27 (7.5)		
	Natural tooth	1,040 (92.1)	89 (7.9)		

*P<0.05.
Values are presented as number of implants (%).
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12. Multiple regression analysis: binary regression model for screw loosening

Variables that were statistically significant in the chi-square testing were used in the multivariate analysis: position, implant diameter, type of retention, and type of prosthesis. Table 9 displays the results of the final binary regression model for screw loosening in dental implants.

Implants placed in the anterior dentition had a 3.024 greater chance of screw loosening than implants placed in premolars. When the ≥5-mm implant diameter group was taken as a reference, the ≤3.5 mm group had a 0.327 lower chance of screw loosening, and the 3.75-4.1 mm and 4.5-4.9 mm groups had 0.566 and 0.433 lower chances of screw loosening, respectively. Screw retention implants had a 1.581 greater chance of screw loosening than cement retention implants. Splinted crowns showed a 0.271 lower chance of screw loosening than single crowns.

IV. Discussion

Jemt et al.[6] reported that screw loosening occurred in 27.3% of 107 single-implant restorations placed in 92 patients. Kreissl et al.[7] reported that 6.7% of 205 fixed-implant restorations placed in 76 patients experienced screw loosening, and Goodacre et al.[14] reported an overall screw-loosening incidence of 6.0%.

In this study, screw loosening occurred in 7.2% of implants, usually once (77.7%), followed by twice (14.4%) and more than twice (7.9%). Most cases happened within six months of loading (50.4%), which is lower than the 53.5% of 43 implants reported by Cha et al.[15] Within a year of loading, 71.3% of the screw loosening incidents we found had occurred, which exceeds the 67.0% reported by Kreissl et al.[7]. Similarly, when screw loosening occurred twice or more, 71.0% of incidents happened within six months after loading.

Table 9. Final binary regression model for screw loosening in dental implants

Variable	Regression coefficient	*P*-value	OR	CI for OR
Constant	–2.173	0.000	0.114	-
Position				
Anterior dentition	1.107	0.003	3.024	1.455-6.287
Premolar dentition	-	-	1	-
Implant diameter (mm)				
≤3.5	–1.117	0.024	0.327	0.124-0.865
3.75-4.1	–0.570	0.016	0.566	0.356-0.898
4.5-4.9	–0.837	0.007	0.433	0.237-0.792
≥5	-	-	1	-
Type of retention				
Cement	-	-	1	-
Screw	0.458	0.033	1.581	1.037-2.409
Type of prosthesis				
Single crown	-	-	1	-
Splinted crown	–1.306	0.000	0.271	0.181-0.405

(OR: odds ratio, CI: confidence interval)
P=0.139; Hosmer–Lemeshow test.
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The incidence of screw loosening did not differ significantly according to sex. Duncan et al.[16] conducted a 3-year retrospective study of 186 implants placed in 51 patients and reported a 9.4% incidence of screw loosening in males, which was much higher than they found in females (3.1%). Lang et al.[17] indicated that applying excessive loading on screws can dissipate the preload, resulting in screw loosening. Shinogaya et al.[18] and Chladek et al.[19] measured the occlusal force in each sex and reported a greater force in males; thus, it can be presumed that the difference in the occlusal force between the sexes leads to the difference in the incidence of screw loosening.

With respect to age, screw loosening was most common in the group older than 70 years (13.5%), though the other groups showed a similar incidence ($P>0.05$). In this study, patients older than 50 years made up 71.8% of the total patient population. In other words, it is likely that screw loosening is more frequent in elderly patients because tooth loss and implant treatment become more common as patients get older.

Screw loosening showed a similar incidence in the maxilla (7.5%) and mandible (6.9%) ($P>0.05$). Simon[20] reported similar results (4.0% in the maxilla and 3.2% in the mandible) in their 10-year retrospective study of patients who received implants. However, Jemt et al.[6] reported a higher incidence of screw loosening in the maxilla (31.0%) than in the mandible (10.5%) in their 1-year retrospective study of single-implant restorations.

Screw loosening was most common in the molar region (8.5%), followed by the anterior (6.9%) and premolar regions (3.8%) ($P<0.05$). The molar region showed a higher possibility of screw loosening because the occlusal force in the molar region is usually greater than that in the anterior region[19]. Cho et al.[8] also reported a higher incidence of screw loosening in the molar region (12.3%) than in the anterior region (7.7%), and they also suggested greater occlusal force as the reason. They suggested that practitioners reduce excessive or off-axial loading on molar implants. Eckert and Wollan[21] observed 1,170 implants in partially edentulous patients and reported differences in the incidence of screw loosening in the maxillary anterior, maxillary posterior, mandibular anterior,

and mandibular posterior implants; nonetheless, they argued that the site of implant placement did not greatly affect screw loosening. In this study, 78.3% of screw loosening in the anterior region occurred in the maxilla. When the mandible moves forward, it is usually guided through the palatal surface of the maxillary anterior tooth, which applies off-axial loading to the implant and could increase the probability of screw loosening[22]. Even when implants are precisely manufactured, small differences can occur in the structure. In addition, the internal surface of the implant can have some rough parts that directly contact the thread of the screw. In a previous study, manufacturing flaws were mentioned as a suspected cause of screw loosening[12]. In addition, Al Jabbari et al.[23] observed that screws from a single manufacturer, as well as those from different manufacturers, can differ in their shapes, microstructures, and microhardness. Those authors suggested that such differences could affect the preload. In fact, it is difficult to make a perfect adaptation for the internal surfaces of implants and screws; thus, there might be premature contact. When loading is applied to the implant, the premature contact surface wears off, which leads to settling, the amount of which depends on the initial roughness and amount of loading applied[10,24]. If a loss of preload occurs afterward, the possibility of screw loosening increases.

Regarding the diameter of the implant, screw loosening mostly occurred when the diameter was ≥5 mm (14.2%) (P<0.05). Boggan et al.[25] compared the static and fatigue strengths of the components in 4-mm and 5-mm diameter implants. They reported that the loading applied to the screw decreases as the diameter increases. Shin et al.[26] measured the torque loss rate as they applied cyclic loading to an implant and reported that the torque loss rate was lower when the diameter of the implant was greater. Cho et al.[8] showed a decreased incidence of screw loosening in wide-diameter implants (5.8%) compared with standard-diameter implants (14.5%), suggesting that a wider diameter is more favorable. On the other hand, we found screw loosening to occur most often in implants with diameters ≥5 mm in this study, unlike in previous studies. Fifty-nine implants showed screw loosening, 56 of which were placed in the molar region. Therefore, we suggest that the position of the implant has a greater effect on the incidence of screw loosening than the diameter of the implant.

In terms of implant length, screw loosening was most common in the 10-11.5 mm range (7.9%). Although Urdaneta et al.[27] reported that an increase in the crown-to-implant length ratio can result in prosthetic complications—including screw loosening—we found a lower incidence in the ≤9.5 mm range (4.6%) in our patient population.

As the types of implant–abutment connections relate to screw-loosening incidence, the external group showed higher incidence (8.9%) than the internal group (5.4%) (P<0.05). In an external implant–abutment connection—which consists of a butt-joint—micromovement of the crown is allowed. Moreover, the center of rotation is high, so it has a low resistance to lateral and rotational forces. These factors cause the high incidence of screw loosening. Furthermore, the weak connection of the implant–abutment interface acts as a fail-safe mechanism in cases of excessive loading[28]. To go beyond those limitations, internal implant–abutment connections with many different structures have been developed. The internal type protects the screw by deeply distributing the lateral force into the inner part of the implant. It also has a wide and solid contact surface. In addition, it lowers the possibility of screw loosening by resisting gap opening in the implant–abutment interface[29]. Piermatti et al.[30] and Tsuge and Hagiwara[31] conducted screw-loosening experiments after the cyclic loading of external and internal connection implants. Contrary to our results, they reported no difference in torque loss between external and internal connection implants. Instead, they suggested that the material or form of the screw plays the most significant role in screw loosening.

The frequency of screw loosening was greater in screw-retained implants (10.1%) than in cement-retained implants (4.9%) (P<0.05). The screw-retained type can easily become separated from the crown when it needs to be repaired, and because the passive fit of the implant superstructure is inferior to that in cement-retained implants, the possibility of screw loosening is increased[32]. Nissan et al.[33] observed screw-retained and cement-retained implants for 15 years and also reported a greater incidence of screw loosening in the screw-retained type (32%±0.3%) than in the cement-retained type (9%±0.2%). As the misfit between the screw joint and the implant superstructure increases, the occurrence of complications such as screw loosening also increases. Cement-retained implants can protect the implant complex because the cement layer compensates for any misfit in the implant superstructure[34,35]. Precautions are necessary because strain can occur in the bone around the implant while the crown is being cemented. Therefore, it is important to accomplish a passive fit in implant prostheses[36].

Screw loosening was most common in single crowns (14.0%), followed by cantilever bridges (11.8%), and splinted crowns (3.4%). Implant-retained overdentures did not show

any screw loosening (P<0.05). Jemt et al.[6] reported that screw loosening is a frequent problem in single implants (27.3%). Cho et al.[8] reported that screw loosening occurred in 10.3% of single implants. Our results showed a high incidence of screw loosening in single implants as well. Balshi et al.[37] suggested that screw loosening is common in single implants because the superstructure of the single implant in the molar region is usually bigger than the diameter of the implant, which allows the bending overload to be applied in every direction. In addition, the occlusal force is high. They also suggested that splinting adjacent dental implants lowers the incidence of screw loosening because the splinting removes the mesiodistal bending. In this study, most single implants were placed in the molar region (464 out of 691 single implants). Also, most screw loosening occurred in the molar area. A careful approach is thus required when placing an implant in the molar area, which exhibits a high prevalence of tooth loss and unfavorable biomechanical conditions. The cantilever structure can also increase the stress on an implant, so practitioners should avoid it, especially in a posterior partially edentulous segment[38].

Haraldson and Zarb[39] conducted research that compared the results from treating both jaws with an implant-supported fixed prosthesis with those from treating one jaw with an implant-supported prosthesis and leaving a natural or fixed partial denture on the opposing jaw. They reported that the former group had lower occlusal force. In our results, implant-to-natural-tooth occlusions showed more screw loosening than implant-to-implant occlusions, though the result was not significant (P>0.05). It is rational to assume that the relatively greater occlusal force of an implant-to-natural-tooth occlusion affected this finding. Likewise, occlusal interference—such as extrusion or wear of the natural teeth—can be an influencing factor, and failure to adjust for that during a prosthetic treatment to accommodate a patient's preference might affect screw loosening. On the other hand, Davis et al.[40] reported that a fracture in the superstructure is more common in implants opposing implants than in those opposing natural teeth, but there was no difference in the screw loosening incidence between those two groups. They explained their finding by noting the lack of tactile sensitivity and proprioceptive feedback from implants.

Thirty-one implants in 24 patients showed screw loosening on two or more occasions, representing 22.3% of the all screw-loosening incidents. Once a screw is loosened, it is corrected by retightening or an occlusal adjustment. When screw loosening recurred in our population, a new screw or crown reproduction was placed, if necessary.

Two implants exhibited screw loosening a total of ten times. One was removed because of its mobility. It is unclear whether there is a relationship between screw loosening and osseointegration failure, but we assume that the stress accompanying screw loosening affected the implant–bone interface.

Bakaeen et al.[41] evaluated the effect of implant diameter, restoration design, and the occlusal table on screw loosening in posterior single-tooth implants. They concluded that wide-diameter (5 mm) implants can cause a higher degree of screw loosening than conventional-diameter (3.75 mm) implants. This result matches our finding in this study. Bakaeen et al.[41] suggested that narrowing the occlusal tables of restorations can reduce the degree of screw loosening.

Implants restored with single crowns have shown more screw loosening than multiple implants with multiple restored units[37]. Our findings in this study are similar: splinted crowns had about 0.3 times less screw loosening than single crowns. To ease the incidence of screw loosening, it is advisable to maximize the joint clamping forces and curtail joint separating forces[9]. An article by Sadid-Zadeh et al.[42] suggested torqueing the abutment or screw-retained crown with twice the force recommended by the manufacturer with an interval of 5 minutes between rotations.

The time of occurrence for screw loosening reported here might be somewhat inaccurate because not all patients visit for regular checkups, and some delay visiting because of personal circumstances despite an occurrence of screw loosening. The types of abutment and screws, materials used in the crown, and occlusal scheme were excluded from our classification criteria because such information is sometimes missing from dental charts.

In addition to the classification criteria used in this study, various other factors can affect screw loosening; therefore, long-term results should be sought in a prospective study. Moreover, an in-depth analysis of recurrent screw loosening is necessary in a future investigation.

V. Conclusion

The findings of our retrospective study, in which 1,928 implants were placed and loaded in 837 patients (448 males and 389 females), are as follows:

1. Screw loosening occurred in 7.2% of the cases. Of those, 22.3% showed repeated screw loosening.

2. Screw loosening normally occurred within six months of loading.

3. With respect to the position of the implant placement, screw loosening was most frequently observed in the molar region.

4. Differences in the occurrence of screw loosening were observed among the different types of implants and manufacturers.

5. Screw loosening occurred most frequently in implants with a diameter ≥5 mm.

6. External implant–abutment connections showed a higher incidence of screw loosening than internal implant–abutment connections.

7. A higher incidence of screw loosening was observed in screw-retained implant prostheses than in cement-retained implant prostheses.

8. Screw loosening was most frequently observed in single crowns, followed by cantilever bridges, splinted crowns, and implant-retained overdentures.

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Authors' Contributions

K.Y.L. participated in data collection and wrote the manuscript. K.Y.L. and K.S.S. participated in the study design and performed the statistical analysis. J.H.J., H.W.C., K.H.K., and Y.L.K. participated in the study design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

This study was conducted after approval from the Institutional Review Board of Wonkwang University Dental Hospital (IRB No. WKDIRB201408-02), and the informed consent was waived.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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