ORIGINAL ARTICLE

https://doi.org/10.5125/jkaoms.2023.49.1.13
pISSN 2234-7550 · eISSN 2234-5930

Effectiveness of ultra-wide implants in the mandibular and maxillary posterior areas: a 5-year retrospective clinical study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2023;49:13-20)

Objectives: Ultra-wide implants may be used as a replacement if existing implants fail. This study was conducted to evaluate the factors influencing the prognosis and failure of ultra-wide implants.

Patients and Methods: This study evaluated whether sex, age, site, diameter, length, additional surgery, implant stability (primary and secondary), and reason for ultra-wide implant placement affect the 5-year survival and success rates and marginal bone loss (MBL) of ultra-wide implants. Seventy-eight ultra-wide implants that were placed in 71 patients (39 males and 32 females) from 2008 to 2010 were studied. One-way ANOVA analysis was conducted to evaluate the statistical significance of MBL according to the patient's sex, implant site, and diameter. Independent sample *t*-tests were used to determine the statistical significance of MBL analysis which was used to determine the significance of the 5-year success and survival rates related to the variables. One-way ANOVA was conducted to evaluate the statistical significance of sex, implantation site, diameter, and MBL. Independent sample *t*-tests were used to evaluate the correlation between implantability and MBL for implantation reasons, while additional surgery, length, and Kaplan–Meier analysis were used to evaluate 5-year survival and success rates.

Results: The mean age of patients was 54.2 years with a survival rate of 92.3% and a success rate of 83.3% over a mean 97.8-month period of observation. MBL averaged 0.2 mm after one year of prosthetic function loading and 0.54 mm at the time of final observation. Success rates correlated with primary stability (P=0.045), survival rates correlated with secondary stability (P=0.036), and MBL did not correlate with any variables.

Conclusion: Ultra-wide implants can be used to achieve secure initial fixation in the maxillary and mandibular molar regions with poor bone quality or for alternative purposes in cases of previous implant failure.

Key words: Implant, Survival rate, Retrospective study

[paper submitted 2022. 12. 28 / revised 1st 2023. 2. 6, 2nd 2023. 2. 15 / accepted 2023. 2. 17]

I. Introduction

In 1951, a titanium spiral osseointegrated implant was introduced by Brånemark. Afterwards, research and development on materials and surface treatments were performed, and various types of implants were subsequently released. In particular, wide implants are useful for various purposes, but a lot of controversy remains over their clinical prognosis.

Implants are classified into narrow, standard, and wide implants according to their implant diameters. Al-Johany et al.[1] defined narrow, standard, and wide diameters as 3.0 to 3.75 mm, 3.75 to 5 mm, and 5 mm or more, respectively. Among wide implants, fixtures with a diameter of 6 mm or more are defined as ultra-wide implants.

Clinically, wide implants have a variety of advantages. Compared to narrow implants, wide implants have increased contact between the bone and the implant surface, resulting in increased osseointegration[2] and force distribution causing the force applied to the crest area to be greatly reduced, which is dynamically advantageous after prosthetic loading[3]. In addition, by using a wide implant, cortical engagement is obtained and load can be applied to the implant immediately[4]. From the biomechanical perspective of improving the high

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initial stability and stress distribution of the supporting bone, wide implants can be used to replace non-integrated fixtures in molars regions. However, if the bone width is insufficient, bony dehiscence may occur frequently due to the excessive pressure applied to the buccal bone with resulting gingival recession[5]. According to Will and Drago[6], the 120 year survival rate of implants with diameters of 7 mm is 97.6%. Similarly, according to Wadhwa et al.[7], the 6-year survival rate of implants with a diameter of 6 mm or more is 97.29%, higher than the standard diameter.

To date, many clinical studies have been published on implants greater than 5 mm but less than 6 mm in diameter, but clinical studies on long-term survival, success rate, and marginal bone loss (MBL) in ultra-wide implants greater than 6 mm in diameter remain sparse. The purpose of this paper is to evaluate the long-term survival rate, success rate, and MBL of 6-mm- and 7-mm-diameter ultra-wide implants and to investigate the variables that affect clinical outcomes.

II. Patients and Methods

This retrospective clinical study was conducted after receiving approval from the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB No. B-2208-774-111).

From January 2008 to December 2010, 81 subjects underwent dental implant placement therapy at the Department of Oral and Maxillofacial Surgery of Seoul National University Bundang Hospital. Eighty-eight ultra-wide implants with diameters of 6 mm and 7 mm were placed in 81 patients. Among them, 1 case was excluded due to the inability of follow-up checks because prosthetic treatment was not conducted at this hospital, 1 case was excluded due to the inability for evaluation because radiographs were not taken at the time of the final observation, and 14 cases within 12 months of the follow-up period after prosthetic loading were excluded from the study. As a result, a retrospective clinical study was conducted on 78 implants placed in 71 patients.

The reasons for using ultra-wide implants were as follows: First, an ultra-wide implant was selected as the initial choice due to poor bone quality. Second, if an implant with a diameter of 5 mm or less was attempted during surgery, but initial fixation was not obtained, an ultra-wide implant was used. Third, an ultra-wide was used for replacement after the removal of failed implants.(Table 1)

All patients underwent surgeries performed by one oral and maxillofacial surgeon, and primary stability was measured during the initial surgery, while secondary stability was measured for ultra-wide implants during the second surgery. All of the patients visited the hospital for a regular one-year check-up and underwent clinical examinations and periapical radiographs. Clinical examinations evaluated pocket depth, suppuration, and pus. MBL values were evaluated with periapical radiographs.

Resonance frequency analysis (RFA) was used to measure implant stability (primary and secondary). In this study, the implant stability quotient (ISQ) was measured and RFA was evaluated using an Osstell Mentor (Gothhenburg, Sweden), an integration diagnostic tool. The ISQ figure was recorded between 0-100 with the manufacturer statement of successful implants being above 65 ISQ, while values below 50 ISQ were the criterion for failure or risk of failure of the implant. Among the placed implants, primary stability was not measured for five implants and secondary stability was not measured for two implants.

The mean age of the patients was 54.2 years old with 39 males and 32 females. The age group in which implants were placed was the largest in their 50s, followed by those in their 60s and 40s.(Table 2) The mean healing period was 22 weeks after implant placement before prosthetic loading. The mean follow-up period for patients was 97.8 months. The

Table 1. Reasons for ultra-wide implants

Type	No. of cases
Initial choice	
Poor bone quality	59
Failed initial fixation of an implant with a diameter of 5 mm or less	3
Replacement after removing the failed implant	16

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Table 2. Number of patients according to age and sex

Variable	No. of patients
Age (yr)	
20-29	2
30-39	4
40-49	15
50-59	28
60-69	19
70-79	3
Sex	
Male	39
Female	32

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Table 3. Number of implants according to a number of variables

Variable	No. of implants
Diameter (mm)	
6	62
7	16
Length (mm)	
8	33
10	38
12	7
Site	
Maxilla	32
Mandible	46
Surgery stage	
One stage	31
Two stage	47
Additional surgery	
Sinus lift only	5
GBR only	31
Sinus lift+GBR	18
No additional surgery	24

(GBR: guided bone regeneration)

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healing period was set as the period from the time of surgery to second therapy or initial impression taking for prosthesis fabrication. The final observation period was set as the period from the time of prosthetic loading to the time of the final visit. The diameter and length of the implant, the implant site (upper/lower jaw), surgery stage, and the presence of additional surgical procedures (guided bone regeneration [GBR] and sinus lift) were evaluated.(Table 3)

The success and survival of the implants and MBL according to the variables were evaluated.

1. Success

The criteria for success were set as follows: (1) Implant exhibiting no mobility, (2) periapical radiograph showing no radiolucency around the implant, (3) MBL within 1 year of prosthetic loading was less than 1.5 mm, and subsequently less than 0.2 mm per year, and (4) no clinical findings such as inflammation, bleeding, pus, and suppuration.

2. Survival

The criteria for survival were set as follows: (1) Implant persistence at the implanted site until the final observation time.

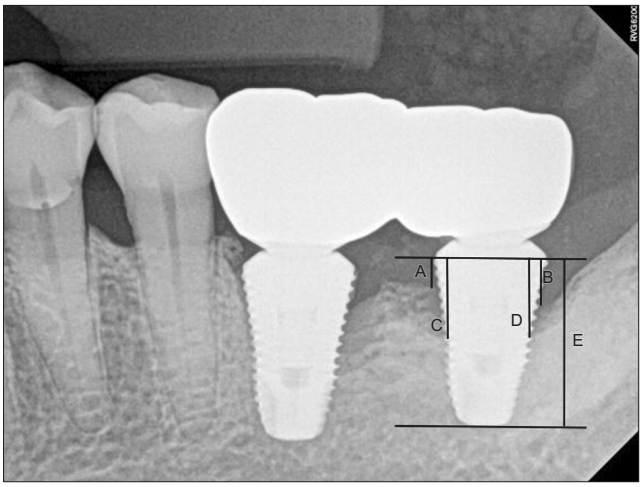

Fig. 1. Landmark of the periapical radiograph. A: marginal bone level of the mesiobuccal aspect, B: marginal bone level of the distobuccal aspect, C: marginal bone level of the mesiolingual aspect, D: marginal bone level of the distolingual aspect, E: length of the implant on the periapical radiograph.

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3. Marginal bone loss

A periapical radiograph that was taken immediately after prosthetic loading was used as the baseline, and MBL was measured by calculating the bone loss of the mesial and distal aspects in the periapical radiograph taken one year after prosthetic loading and at the final observation time. The magnification rate was calculated by measuring the length of the actual implant, the length of the implant measured on periapical radiograph, and the MBL observed on periapical radiograph. (Fig. 1)

$$\text{MBL}=\frac{\text{MBL on periapical radiograph}\times\text{Actual implant length}}{\text{Implant length on periapical radiograph}}$$

One-way ANOVA analysis was used to evaluate the statistical significance of MBL according to the patient's sex, implant site, and diameter. Independent sample *t*-tests were used to determine the statistical significance of MBL according to the reason for ultra-wide implants, length, additional surgery, primary implant stability, and secondary implant stability.

Kaplan–Meier analysis was used to determine the significance of the success and survival rates related to the variables (age, sex, site, diameter, length, additional surgery, reason for ultra-wide implant, implant primary stability, and implant secondary stability). All data were evaluated using IBM SPSS Statistics (ver. 28.0.1; IBM, Armonk, NY, USA), which tested

Table 4. Summary of failed implants

Reason[1]	Age (yr)	Sex	Site	D/L	Additional surgery
A	55	F	Mn	6D/8L	
	62	M	Mn	6D/8L	
	59	F	Mn	6D/8L	GBR
	54	M	Mx	7D/10L	GBR
B	51	M	Mn	6D/8L	GBR
	63	M	Mx	6D/12L	GBR
C	49	F	Mx	6D/12L	
	72	F	Mx	6D/8L	GBR, sinus lift
D	47	M	Mx	6D/12L	GBR
	44	F	Mn	6D/10L	
	54	F	Mn	6D/10L	
	60	F	Mn	6D/10L	GBR
E	69	F	Mx	7D/12L	GBR, sinus lift

(F: female, M: male, Mn: mandible, Mx: maxilla, D: diameter, L: length, GBR: guided bone regeneration)
[1]A: exhibited mobility, B: exhibited radiological radiolucency, C: 0.2 mm or more annual marginal bone loss since the first year of prosthetic loading, D: 1.5 mm or more of marginal bone loss within the first year of prosthetic loading, E: exhibited inflammation and bleeding.
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the significance of any association at a 95% confidence level.

III. Results

1. Success rate

During the mean observation period of 97.8 months, the success rate of the ultra-wide implants was 83.3%. A total of 13 implants failed during the observation period; (1) Four implants were removed due to mobility, (2) two implants exhibited radiological radiolucency around the implants, (3) two implants demonstrated 0.2 mm or more of annual MBL since the first year of prosthetic loading, (4) four implants exhibited 1.5 mm or more of MBL within the first year of prosthetic loading, (5) one implant exhibited inflammation and bleeding around the implant.(Table 4)

If the primary stability was less than 60, the success rate was 61%, 100% between 60 and 70, and 91.2% between 71 and greater, exhibiting statistically significant differences. In addition, there was no statistically significant difference in age, sex, implant site, implant diameter and length, additional surgery, secondary implant stability, and reason for ultra-wide implants.(Table 5)

2. Survival rate

The survival rate of ultra-wide implants was 92.3% during a mean observation period of 97.8 months. Four implants were removed due to mobility, while two implants were removed due to osseointegration failure as radioluncency around the implants increased.

There was a statistically significant difference of 87.5% (P=0.036) when the secondary stability was 71 or greater, the survival rate was 100%, and when primary stability values were between 60 and 70. There was no statistically significant difference between the other variables and the survival rate of implants.(Table 6)

Table 5. Success rates according to numerous variables

Variable	Success rate (%)	P-value
Age group		0.698
20s	100	
30s	100	
40s	81.25	
50s	87.5	
60s	76.1	
70s	66.7	
Sex		0.248
Male	86.36	
Female	79.41	
Site		0.823
Maxilla	81.25	
Mandible	84.78	
Diameter (mm)		0.331
6	82.26	
7	84.7	
Length (mm)		0.532
8	84.8	
10	89.47	
12	42.87	
Additional surgery		0.722
Sinus lift only	100	
GBR only	92	
Sinus lift+GBR	94.4	
No additional surgery	78.6	
Implant stability		0.045*
Primary		
<60	61	
60-70	100	
>70	91.2	
Secondary		0.724
<60	-	
60-70	87.5	
>70	90.3	
Reason for ultra-wide implants		
Initial choice		0.766
Poor bone quality	100	
Failed initial fixation of an implant with a diameter of 5 mm or less	88.6	
Replacement after removing the failed implant	100	

(GBR: guided bone regeneration)
*P<0.05; statistically significant.
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Table 6. Survival rate according to numerous variables

Variable	Survival rate (%)	*P*-value
Age group		0.547
20s	100	
30s	100	
40s	100	
50s	90.62	
60s	85.7	
70s	100	
Sex		0.639
Male	88.6	
Female	97.05	
Site		0.147
Maxilla	93.75	
Mandible	91.30	
Diameter (mm)		0.390
6	91.9	
7	93.75	
Length (mm)		0.141
8	87.88	
10	97.37	
12	85.7	
Additional surgery		0.349
Sinus lift only	100	
GBR only	75	
Sinus lift+GBR	91.8	
No additional surgery	93.1	
Implant stability		
Primary		0.667
<60	91.7	
60-70	100	
>70	95	
Secondary		0.036*
<60	-	
60-70	87.5	
>70	100	
Reason for ultra-wide implants		
Initial choice		0.641
Poor bone quality	100	
Failed initial fixation of an implant with a diameter of 5 mm or less	94	
Replacement after removing the failed implant	100	

(GBR: guided bone regeneration)
*P<0.05; statistically significant.
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Table 7. Marginal bone loss (MBL) according to a variety of variables

Variable	MBL (mm)	*P*-value
Age group		0.463
20s	0.00	
30s	0.00	
40s	0.559	
50s	0.417	
60s	0.642	
70s	1.119	
Sex		0.071
Male	0.294	
Female	0.752	
Site		0.431
Maxilla	0.389	
Mandible	0.586	
Diameter (mm)		0.060
6	0.580	
7	0.186	
Length (mm)		0.138
8	0.672	
10	0.278	
12	1.018	
Additional surgery		0.069
GBR	0.602	
No GBR	0.319	
Implant stability		
Primary		0.326
<60	0.17	
60-70	0.18	
>70	0.60	
Secondary		0.494
<60		
60-70	0.21	
>70	0.43	
Reason for ultra-wide implants		
Initial choice		0.059
Poor bone quality	0.34	
Failed initial fixation of an implant with a diameter of 5 mm or less	0.57	
Replacement after removing the failed implant	0.00	

(GBR: guided bone regeneration)
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3. Marginal bone loss

After one year of prosthetic loading, MBL was 0-2.3 mm (mean, 0.2 mm), and at the time of final observation, MBL was 0-4.99 mm (mean, 0.54 mm). There was no statistically significant difference between any variable and MBL.(Table 7) Four cases were recorded where MBL of 1.5 mm or greater was observed after one year of prosthetic loading.(Table 4)

VI. Discussion

The ultra-wide implants used in this study were SuperLine (Dentium, Suwon, Korea), which has characteristics of SLA (sandblasted, large-grit, acid-etched) surface treatment, an internal connection, 6.0- or 7.0-mm diameter, tapered shaped, and are used when bone quality is poor or the placement of standard diameter implants has failed.

Since wide implants increase initial stability through stress distribution while engaging bone, they are selected as initial implants when bone quality is poor. In this study, 59 implants were placed for that reason, while three implants were used as replacements of implants that were less than 5 mm in diameter and failed to achieve initial stability. According to the characteristics of the ultra-wide implants exhibiting high initial stability, the ultra-wide implants placed in the study by Hattingh et al.[2] were immediately loaded after molar tooth extraction. Ultra-wide implants are sometimes called a 'res-

cue implant' if the existing implant has failed and the ultra-wide implant is used for alternative purposes[8]. In this study, 16 cases of ultra-wide implants were placed after removing the failed implants. If the previous implant failed and was removed, the range of bone defects increased. If implant placement was possible immediately, primary stability could be secured during the placement of 6-mm- and 7-mm-diameter ultra-wide implants. According to Hattingh et al.[9], ultra-wide implants reduce the need for bone augmentation compared to standard diameter implants. In this study, 29 implants were used without GBR[9].

In the mean 97.8-month follow-up period of ultra-wide implants used in this study, the long-term survival rate was 92.3% with an 83.3% success rate. MBL was 0.2 mm one year after prosthetic loading and 0.54 mm in the mean 97.8-month follow-up period. In Hattingh et al.'s study[9] where 580 cases of 7-mm-diameter ultra-wide implant were placed in molar sockets, the 10-year survival rate was 95.17%. In Ku et al.'s study[10] where 58 cases of 6-mm or wider diameter ultra-wide implant were placed, the survival rate in the mean 46.25-month follow-up period was 98.28%. In addition, MBL was 0.018 mm and 0.045 mm on mean for 12 months and 24 months after prosthetic loading, respectively, and MBL was 0.14 mm during the follow-up period of 46.25 months.

In this study, ultra-wide implants exhibited a low success rate (83.3%) and survival rate (92.3%). According to Ketabi et al.[8], greater torque force is needed when placing large-diameter implants, and a bone thickness of 1.8-2 mm is required on the buccal and lingual/palatal sides. The success of ultra-wide implants may have been affected due to insufficient bone thickness and density, as they were placed in cases of poor bone quality or as replacements for failed implants. Furthermore, previous studies support the significant lower survival rate when replacing implants in failed locations. According to Chrcanovic et al.[11], the survival rate of the first implant was 94%, but after removing and replacing the failed implant, the survival rate was 73%. Similarly, according to Agari and Le[12], the survival rate of the first implant was 95.4%, but after re-implanting in the location of the failed implant, the survival rate was 77.4%, exhibiting a significant difference. The low survival rate of ultra-wide implants can be explained by the fact that it was placed as a replacement for a failed implant.

Among age, sex, site, diameter, length, additional surgery (GBR or sinus lift), and reason for using ultra-wide implants, none exhibited an effect on the success rate of wide implants. Ting et al.[13] reported that patients' age, implant length, and site did not have an influence on the success rate of implants. Meanwhile, Termeie et al.[14] concluded that narrow implants have lower success rates because the narrower the diameter, the greater the stress on the implant. In this study, success rates were higher in wider implants with 91.9% in 6-mm-diameter implants and 93.75% in 7-mm-diameter implants, but no statistical significance was observed. Bazrafshan and Darby[15] proposed that implant success rates with or without GBR exhibited no statistical significance, mirroring our study.

Primary implant stability is mainly related to mechanical stability, which represents engagement in the cortical bone[16]. Primary implant stability has a statistically significant correlation in 5-year implant success rate. The success rate was 61% in cases of less than 60, 91.2% in more than 70, and 100% in between 60 to 70.

Table 4 presents the failed cases shown in this study. Six implants failed in the maxilla, 7 in the mandible, 5 in males, and 8 in females. Eight implants underwent GBR, while 5 did not. Diameter, additional surgery such as GBR or sinus lift, and implant site did not exhibit a statistically significant correlation with implant failure.

As a result of evaluating the factors affecting implant survival rate, none of the variables among age, sex, site, diameter, length, additional surgery (GBR or sinus lift), and reason for using ultra-wide implants had an influence on the survival rate of ultra-wide implants. This was similar to the result of the Cobo-Vázquez et al.[17] study of 92 implants which proposed that primary implant stability did not have an effect on implant survival rate. Furthermore, according to Huwiler et al.[18], primary implant stability was affected not only by the bone volumetric density, but also by the thickness and density of the alveolar bone cortical layer, a good indicator of mechanical anchorage at the time of placement.

However, implant success rates exhibit a significant correlation between secondary implant stability. The success rate was 100% in ISQ values of 70 or more and 87.5% in ISQ values between 60 and 70. This result is similar to Rodrigo et al.'s study[19] which measured implant stability after implant placement, before prosthetic loading, and divided implants into group of ISQ values above and below 60. The success rate of implants with ISQ values above 60 was 99.1% and below 60 was 97.2%. Implant secondary stability referred to the degree of osseointegration with bone remodeling and formation on the implant surface[20]. In other words, as the bone-implant contact ratio increased, secondary stability increased.

Therefore, implants can resist prosthetic loading, which is beneficial to long-term survival.

None of the variables affected the MBL of ultra-wide implants. Deger et al.[21] reported that the difference in MBL according to the diameter and length of the implant did not exhibit a statistical significance. The main cause of implant loss was occlusion overload with small stresses applied to the apical aspect of implants. Therefore, the effect of implant length was insufficient. In other words, it can be determined that the effect of the length of the implant on crestal bone strain is minimal.

According to Ibañez et al.[22], they obtained the same result found in the current study where the implant site is not a variable affecting MBL. There was no difference in MBL depending on the presence of additional surgery. According to Park et al.[23], in the implant group with sinus lifts, 3.15±2.50 mm of MBL was observed, while 3.15±2.61 mm of MBL was observed in the group without sinus lifts, exhibiting no difference in MBL. Likewise, the findings from Zumstein et al.[24] were consistent with the results of a study in which MBL did not exhibit a statistically significant correlation between GBR and the lack of GBR.

Through long-term observation of ultra-wide implants (diameters of 6 mm or more), this study investigated the survival rate, success rate, and MBL of ultra-wide implants. However, one limitation was that the sample size was small. Due to the characteristics of most retrospective studies, the evaluation of systemic diseases and smoking can be inaccurate. In addition, if patients have one or more systemic diseases, it is not possible to determine whether medical treatment is done well. Therefore, systemic diseases were not set as variables.

V. Conclusion

Wide implants are alternatives that can be selected in situations of poor initial fixation or failure of existing implants in the maxilla and mandible. In terms of age, sex, site, diameter, length, additional surgery, reason for ultra-wide implants, implant primary stability, and implant secondary stability, success rate correlated with primary implant stability, survival rate correlated with secondary implant stability, and MBL did not exhibit correlation with any variable.

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Authors' Contributions

S.Y.K. participated in data collection and wrote the manuscript. H.G.K. participated in the study design and coordination and helped to draft the manuscript. Y.K.K. and P.Y.Y. participated in the data collection. All authors read and approved the final manuscript.

Funding

No funding to declare.

Ethics Approval and Consent to Participate

This prospective clinical study was conducted after receiving approval from the Institutional Review Board of Seoul National University Bundang Hospital (IRB No. B-2208-774-111), and the written informed consent was obtained from all the patients.

Conflict of Interest

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

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How to cite this article: Kim SY, Kim HG, Yun PY, Kim YK. Effectiveness of ultra-wide implants in the mandibular and maxillary posterior areas: a 5-year retrospective clinical study. J Korean Assoc Oral Maxillofac Surg 2023;49:13-20. https://doi.org/10.5125/jkaoms.2023.49.1.13