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CLINICAL RESEARCH

A comparison of implant complications and failures between the maxilla and the mandible

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ABSTRACT

Statement of problem. Identifying factors that affect the clinical outcomes of implant therapy is important.

Purpose. The purpose of this retrospective study was to determine whether implant location was a factor affecting the complication and failure rates of single-tooth implant-supported restorations in a predoctoral setting.

Material and methods. The charts of 431 patients treated with a surgically placed dental implant and restored with a single crown in the predoctoral clinic were analyzed. Data on implant location, type of complication (surgical or prosthetic), and type of failure were collected and analyzed according to implant location using the Fisher Exact Test and Mantel-Haenszel Exact Chi Square Test analysis (α=.05).

Results. The charts revealed 158 complications (68 surgical and 90 prosthetic) in 110 patients, and 3.9% of the implants failed. No statistically significant difference was found between the number of surgical complications or prosthetic complications in the maxilla and the mandible (P=.469).

Conclusions. Jaw location (maxilla compared with mandible) of the implant had no statistically significant impact on the incidence of surgically or prosthetically related complications. No statistically significant difference was found in overall implant failures, surgical failures, and prosthetic failures between maxillary and mandibular implants. (J Prosthet Dent 2019;121:611-7)

Although implant success rates are high, complications do occur.[1-4] Research studies have evaluated the clinical outcomes of dental implants to determine the risk factors affecting complication and survival rates.[5-9] Studies have linked implant success to the quality of the bone.[10,11] Lekholm and Zarb[12] classified bone quality based on the amount of cortical and trabecular bone. Their 4-tiered classification system ranged from bone with a thin layer of cortical bone surrounding low-density trabecular bone (Type IV) to homogenous dense cortical bone (Type I). Type IV bone is characterized as being of poorer quality for implant placement than Type I bone.

Truhlar et al[13] attempted to determine whether a correlation exists between bone quality and jaw location. Their findings linked bone quality to jaw location. Therefore, a correlation may exist between implant complication and failure rates and location in the maxilla or mandible.[10,11] Studies attempting to examine jaw location as a risk factor for failure or complications have primarily investigated the risk factor at the level of the implant.[14-16] Studies have also investigated multiple implants within an individual and multiple restoration types within the study, often not attempting to control for these factors. This may explain why the literature contains contradictions indicating that either the maxilla or mandible is more associated with failure or complication.

The definition of an implant failure has varied among studies.[17-22] Failure may be divided into 2 categories: surgical and prosthetic. Surgical failures and complications occur before the restoration. Surgical complications may involve nerve impairment, postoperative infection, failure of osseointegration, or implant or bone loss before loading.[23] Prosthetic failures may occur during and after placement of the restoration. Prosthetic complications involve loss of or damage

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Clinical Implications

Based on the results of this study, maxillary or mandibular jaw location does not affect the failure or complication rate of single-tooth implant-supported restorations.

to the prosthesis and may lead to loss of the dental implant. For example, the loss of an implant linked to overload of the prosthesis is considered a prosthetic failure after prosthesis placement. Surgical complications that are technical in nature may include incorrect surgical positioning or incorrect angulation of the implant.

To improve clinical outcomes, the prevalence of surgical and prosthetic complications, failure rates, and the relation with the implant's location in the maxilla or mandible must be understood. The purpose of this retrospective study was to determine whether implant location (maxilla or mandible) was a factor affecting the complication and failure rates of single-tooth implant-supported restorations.

MATERIAL AND METHODS

The protocol was approved by the Case Western Reserve University Institutional Review Board. Using the Case Western Reserve University School of Dental Medicine database, 431 patients were identified for inclusion. The sample size was determined based on the number of patients who had had a dental implant surgically placed with a single-crown restoration in the predoctoral clinic between 2008 and 2011. No attempt was made to collect data or track by treating dental student. Over the course of 4 years, 300 dental students treated patients with dental implant in the predoctoral clinic. These students were supervised by faculty who were calibrated by means of departmental standards of care, seminars, and hands-on exercises. During this same time, 8 oral maxillofacial surgery residents and 8 periodontics residents placed dental implants. Only 1 dental implant system was used to treat these patients, that is, Nobel Biocare Replace (Nobel Biocare).

Data were tabulated in a spreadsheet (Excel 2010; Microsoft Corp). The following measures were collected: implant location (tooth number), implant diameter and length, type of crown (cement retained versus screw retained), and type of complication.

Complications were divided into surgical and prosthetic complications. These categories were further divided into biological and technical complications. The surgical biological complications included nonintegration, nerve impairment, postoperative infection, fistula, exudate, ulceration, soft-tissue inflammation, gingival recession, and bone loss. Technical complications included incorrect position/angulation of the implant, an implant of a size other than that requested by the referring dentist, and loose healing abutments. Nerve impairment in this study was defined as any notation indicating prolonged paresthesia or anesthesia. If any complaint from the patient regarding these symptoms was recorded in the chart, a positive response for nerve impairment was recorded.

The data were treated as observational data; either the complication existed or it did not. If the chart entry indicated that it was observed by the student clinician or was a complaint of the patient, it was treated as a positive observation. Because this was a retrospective study reviewing charts, the data were analyzed based on whether the chart entry indicated the presence of a particular finding. No attempt was made to quantify any aspect of the complication or failure. No attempt was made to quantify the amount of tissue recession or marginal bone loss as the examiners and radiographs were not calibrated.

Prosthetic complications were also divided into biological and technical groups. Biological complications included pain associated with the crown at the time of seating and mobility of the implant after crown placement. The technical prosthetic complications included a loose crown, ceramic fracture requiring remake, ceramic chipping not requiring remake, loose abutment screw, fractured abutment screw, poor crown esthetics, and crown needing occlusal adjustment. Crowns were considered to be esthetic unless otherwise noted in the chart. If the chart entry indicated that the crown was esthetically unacceptable as judged by the student clinician or patient, the crown was deemed unesthetic.

For data-collection purposes, once the crown was placed, any implant deemed mobile upon examination after crown placement and/or subsequent implant failure was attributed to a prosthetically related cause rather than a surgically related cause. Prosthetic and surgical complications were reported separately. If a patient reported multiple prosthetic complications or multiple surgical complications within a category, it was counted once for each category subset in the prosthetic or surgical category.

The implant was considered a success if it remained in the patient's mouth and was in function. Any implant that did not osseointegrate or failed before restoration placement was considered a surgical failure. Any implant integrated before the placement of the restoration that failed subsequent to crown placement was considered a prosthetic failure. The survival rates of the prosthesis and the implant were computed accordingly.

Table 1. Number of implants placed by year

	Year of Implant Placement				
Implant Status	**2008**	**2009**	**2010**	**2011**	**Total**
Survived	77	108	139	90	414
Failed	3	3	5	6	17
Total	80	111	144	96	431

Table 2. Frequency of implant failure by location

	Number of Implants Placed (% of Total by Jaw)		
Location	**No Failure**	**Failure**	**Total**
Mandible	210 (96.77)	7 (3.23)	217
Maxilla	204 (95.33)	10 (4.67)	214
Total	414	17	431

Study data were grouped according to implant location, that is, implants located in the maxilla and implants located in the mandible. The Fisher Exact Test was used to analyze differences in failure rates by implant location. A Mantel-Haenszel Exact Chi Square Test analysis compared differences between the types of complications by implant location (α=.05 for both tests).

RESULTS

Participants' age ranged between 18 and 83 years and included 211 women and 220 men. Each patient received 1 dental implant for a total of 431 dental implants. There were a total of 214 maxillary implants and 217 mandibular implants. No statistically significant difference was found between the maxillary and mandibular implant with regard to age (P=.483) or sex (P=.630). A significant difference was found between the groups with regard to implant length and diameter (P<.001). Rank order determined that in the mandible, the length of the implants was statistically more often ≤10 mm, whereas in the maxilla, the implant lengths were more often ≥13 mm. In contrast, mandibular implants were of a larger diameter (>5 mm), whereas maxillary implants were of a narrower diameter (≤4.3 mm).

Table 1 depicts the distribution of successful and failed implants by the year the implant was placed. The average length of survival time of a successfully restored implant was 2.4 years. The range of the length of time a restoration had been in place was 1 to 4 years. A total of 17 implants failed over the course of the study review, representing a 3.9% failure rate. The failure rates were examined based on type of failure, both surgical and prosthetic. Twelve implant failures were identified as surgical failures, whereas 5 failures were prosthetically related.

Table 2 depicts the total number of failures by location. No difference was found between the number of failures in the 2 groups (P=.469). Of the 10 implants that failed in the maxilla, 8 implants (3.7% of the maxillary implants) were surgical failures, and 2 implants (0.9% of the maxillary implants) were prosthetic failures. In the mandible, 4 implants (1.8% of the mandibular implants) were surgical failures, and 3 implants (1.4% of the mandibular implants) were prosthetic failures (Fig. 1).

Of the 431 implants, 321 implants exhibited no complications, whereas 158 complications were reported to have complications, 68 surgical and 90 prosthetic in nature. The chart review revealed that 110 patients experienced some type of complication. If a patient reported multiple complications, each type of complication was counted once. Table 3 shows the overall number of complications by jaw location. No statistical differences were found between the total number of complications or between the distribution of implants that had more than one complication for implants in the maxilla compared with the mandible (P=.949).

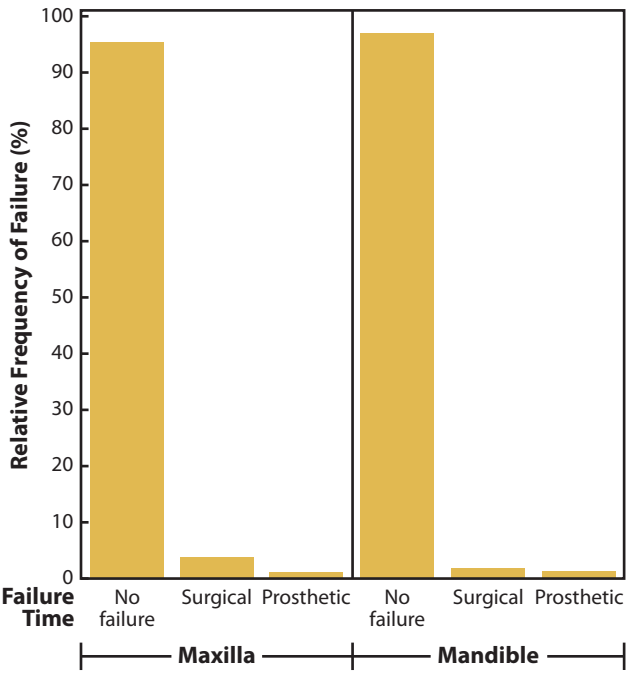

Figure 1. Timing and frequency of failures by location.

Because multiple complications (both prosthetic and surgical) occurred in the same implant, the distribution frequency of surgical and prosthetic complications was also examined. Figure 2 illustrates the rank order of prosthetic and surgical complication. Given that an implant could exhibit neither a surgical nor prosthetic complication or could exhibit one or both types of complications, the graph in Figure 2 indicates the frequency (number) of each type of complication separately. The type of complication (prosthetic or surgical) was analyzed by normalizing the type of complications to the implant. There were 38 patients with mandibular implants and 38 patients with maxillary implants who reported at least 1 type of prosthetic complication. Of the implants that

Table 3. Relative frequency of complications for each location: rank order

	Number of Complications (% of Total Number per Jaw)						
Location	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
Mandible	161 (74.19)	40 (18.43)	11 (5.07)	3 (1.38)	2 (0.92)	0 (0.00)	217
Maxilla	160 (74.77)	37 (17.93)	13 (6.07)	2 (0.93)	0 (0.00)	2 (0.93)	214
Total	321	77	24	5	2	2	431

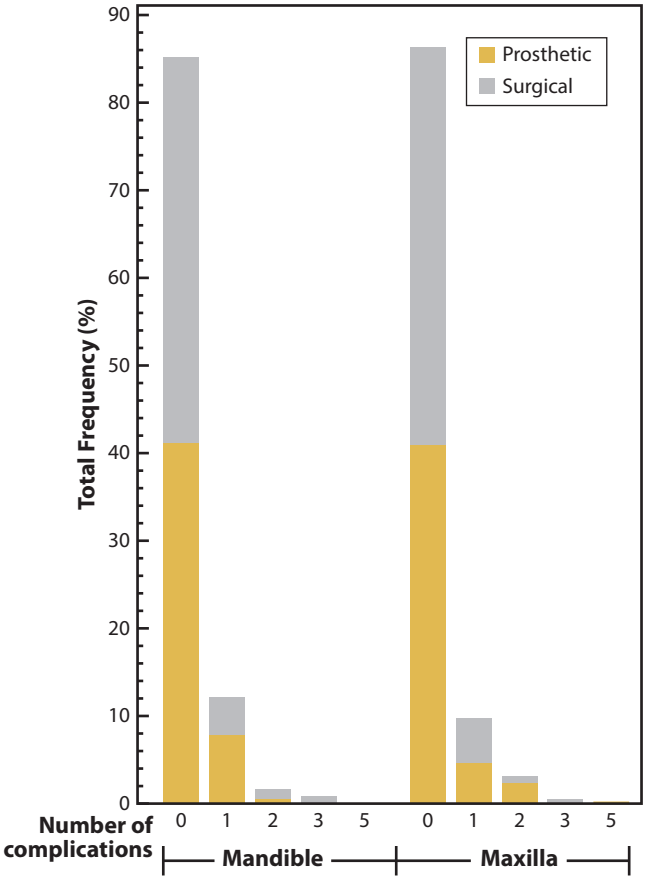

Figure 2. Overall relative frequency of total prosthetic and surgical complications.

experienced a prosthetic complication in the mandible, 3 implants experienced 2 complications, whereas in the mandible, 11 implants experienced 2 types of prosthetic complications. Surgical complications were exhibited in 26 mandibular implants and 20 maxillary implants. Of those who reported some type of surgically related complication in the mandible, 18 implants experienced only 1 complication, 4 implants exhibited 2 complications, and 4 implants experienced 3 complications. In the maxilla, 15 implants experienced only 1 complication, 2 implants exhibited 2 complications, 2 implants experienced 3 complications, and 1 implant exhibited 5 surgical complications. No statistically significant difference was found in the number or the frequency distribution of reported surgically related complications by implant in the mandible or in the maxilla (P=.502). No statistically significant difference was found in the number or frequency distribution of reported prosthetically related complications by implant in the mandible or in the maxilla (P=.387).

Table 4. Number of surgical complications—biological

Complication	Mandible, *n*=217	Maxilla, *n*=214
Nerve impairment	1	0
Infection	10	5
Fistula	0	3
Pus/exudate	5	9
Ulceration	2	0
Inflammation	7	3
Tissue receded	1	1
Bone loss	7	11

n=number of implants.

Table 4 presents an itemization of the biologically related surgical complications. The itemized data are included for completeness; however, the limited frequency of occurrence within the subcategory level did not warrant statistical analysis, which is why it was analyzed as pooled prosthetic or surgical complications. Only 3 types of surgical complications were technical in nature: (1) implants incorrectly positioned, (2) loose healing abutments, and (3) the size of the implant placed not being the size requested. One implant in each jaw was incorrectly positioned; 6 maxillary implants and 5 mandibular implants had loose healing abutments; and 1 maxillary implant was not of the requested size. This represents 0.09% of the complications recorded and 0.03% of the implants placed.

Only 4 recorded incidences of biologically related prosthetic complications were found. One implant in the maxilla presented with mobility, whereas pain from seating of the implant crown was recorded once in the maxillary arch and twice in the mandibular arch. All other prosthetic complications were technical in nature. Table 5 provides the data for the technically related prosthetic complications for implants in the maxilla compared with the mandible. Loose definitive crowns and loose abutment screws were the most common prosthetic complications.

DISCUSSION

Weyant[24] reported that as a surgeon's experience grows, the likelihood of peri-implant soft-tissue health problems decreases. Similarly, Cosyn et al[25] reported that a surgeon's experience level had a significant impact on implant failure. In the present study, all implants were placed by postdoctoral students in residency programs. All prosthetic treatment was completed by a third- or fourth-year dental student. The overall number of failures in the study was 17 implants, representing a 3.9%

Table 5. Number of prosthetic complications—technical

Type of Complication	Mandible, *n*=217	Maxilla, *n*=214
Loose definitive crown	13	16
Fractured definitive crown	1	3
Chipped definitive crown	2	1
Abutment loose	11	14
Abutment fractured	1	2
Restoration not esthetic	4	5
Occlusal contact	7	6

n=number of implants.

failure rate. This failure rate is comparable to those reported for experienced[8,22] as well as novice[25,26] clinicians.

Excluding implant failure, 158 incidences of complications were recorded in 110 charts. This represents a complication rate of 25.5% in the patient population. The types and incidence of the complications were similar to those reported by Goodacre et al,[1] suggesting that the lack of experience of the dental student had no impact on the complication and failure rates reported.

The data of the present study revealed that 11% of the implants placed had some type of surgical complication. No statistical difference was found in the incidence of surgical complications in either jaw. Therefore, no association could be made between implants located in the maxilla or mandible and surgical complications.

Tiriduzzi et al[9] demonstrated a total implant complication frequency of 18.9%. Their results indicated that implants located in the maxilla were statistically associated with increased surgical and prosthetic complications. Their findings conflict with the findings in the present study. Differences in study protocol may account for this difference. In their study, they selected 340 of 1150 implants placed in 340 patients with various types of implants and various types of prosthesis; implants supporting 302 crowns and 38 removable prostheses comprised the study population. Their investigation did not calculate rank order of incidence of complication, making it difficult to determine whether multiple incidences occurred in the same patient. The type of prosthesis or whether the implant studied was splinted to another implant as part of a prosthesis was not indicated. All implant data were pooled, with the examination occurring at the implant level. The authors indicated that prosthesis type affected implant complications. There was no control for variables associated with prosthesis type compared with the present study, which was limited to single-crown implants. The authors did not control for variables related to the dental implant. The present study controlled for these variables using the same implant system for all patients. Furthermore, inflammatory complications were examined separately. Surgical complications were limited to accidental placement of the implant in the sinus, inferior meatus, or submandibular gland and paresthesia for at least 7 days. The data from practitioners with less than 15 years of experience were excluded from the study, whereas in the present study, all practitioners had less than 15 years of experience.

Prosthetic complications were found in 17.5% of the mandibular and 17.8% of the maxillary implants in the present study. More than 1 type of prosthetic complication was exhibited in 1.4% of the mandibular and 5.1% of the maxillary implants. The present study results show no significant difference in the mandible compared with the maxilla with regard to the various prosthetic complications. These results are in agreement with those of Rammelsberg et al,[16] whose Cox regression analysis of 1909 implants (557 single crowns) found no effect of location (maxillary/mandibular or anterior/posterior). Their study examined both single crowns and fixed dental prostheses, but their findings did not discern results based on prosthesis type.

The present study is in agreement with the study by Eckert and Wollan,[6] who reported that implant location had no effect on implant survival, implant fracture rate, screw loosening, or screw fracture. Eckert et al[6] examined patients with partial edentulism who were restored with fixed implant-supported dental prostheses. Although the patient may have had more than one tooth replaced by dental implants in their dental arch, there was always some remaining teeth within that arch. In their study, they examined both the jaw (maxilla versus mandible) and location within the jaw (anterior versus posterior) and found no effect on the frequency of complications or survival.

Several studies disagree as to the influence of implant location on implant survival. Moy et al[8] reported a statistically significant difference ($P<.001$) between implant failure in the maxilla and in the mandible, with more failures reported in the maxilla. In their study, participants received 1 to 5 implants of different types of machined surfaces. Whether multiple failures occurred within the same participant or how many of these participants received single implants was not reported. The participants were not grouped according to prosthesis type, rather a multilinear analysis was performed based on implant location and coexisting conditions such as smoking, diabetes, and sex.

Cosyn et al[25] analyzed the impact of implant location, surgical protocol, loading protocol, surgeon's experience level, and specialty of the surgeon on implant failure. Only loading protocol was shown to have a significant influence on failure. Using a multivariate analysis, Cosyn et al[2,25] concluded that implant location had no significant impact on implant failure. Holahan et al[27] and Eckert and Wollan[6] found that arch location had no effect on implant survival rates. The results of the present

study agreed with those of Holahan et al[27] and Eckert and Wollan,[6] in which no statistically significant difference was found in overall failure, surgical failure, or prosthetic failure in the mandible compared with the maxilla.

The variation in the results of these studies illustrates the complexity of the problem being studied and the need for greater numbers of studies with similar protocols and greater numbers of participants. Few studies[2,14,16,25] examining this issue have been prospective in nature. All the studies examining implant location as a risk factor for implant failure or complications pooled implants restored with various types of prosthesis to have a large number of implants to examine. Although this practice may help enlarge the number of implants to evaluate, it adds a further complexity to the analysis to compensate for the additional variables. The authors are unaware of another study examining location as a risk factor for single-tooth implant restorations at both the implant and patient level.

Like all retrospective studies, this study has limitations because of the nature of chart reviews and the clinician recording the events of the treatment appointment accurately. In the present study, all chart entries were countersigned by a licensed dentist who supervised the treatment. Fifty percent of the charts were reexamined by both the initial data collector and a secondary examiner to verify accurate data collection.

Although the sample represented the entire population of patients who received single-tooth implants over the course of the study period, a post hoc power analysis test was computed.[28] The power of the experimental design was 80%. The sensitivity analysis determined that given an overall failure rate of 3.9%, the experimental design with the sample size and relative overall frequency would have detected a failure frequency as low as 0.1% or as high as 11.6%. As for complication frequencies, given the overall complication rate of 26.2%, the experimental design would have found a complication frequency as low as 14.9% or as high as 39.4%. Neither of these ranges excludes clinical significance; a higher power would only have widened these ranges.

CONCLUSIONS

Based on the findings of this retrospective study of 431 patient records, the following conclusions were drawn:

1. Jaw location (maxilla compared with mandible) of the implant had no statistically significant impact on the incidence of surgically related complications ($P<.05$).
2. Jaw location (maxilla compared with mandible) of the implant had no statistically significant impact on the incidence of prosthetically related complications ($P<.05$).
3. Almost all (96%) of the implants were in function at the time of data collection.
4. No statistically significant difference was found between maxillary and mandibular overall implant failures, surgical failures, or prosthetic failures.

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Noteworthy Abstracts of the Current Literature

Retrospective 9-year clinical outcome report on adhesive post-endodontic treatment of anterior teeth using prefabricated fiber posts

Cerny D, Eckert S, Mounajjed R

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Purpose. To evaluate survival rates of adhesive post-endodontic buildups made using composite resin and prefabricated quartz fiber posts.

Material and methods. This retrospective study included all buildups placed between January 1, 2008, and December 31, 2012, by a single skilled operator using a single-adhesive system and dual-curing cement. Final restorations included direct composites, various types of crowns, and fixed partial dentures. During recall, teeth were inspected by four different dentists, and survival analysis was performed using Kaplan-Meier test.

Results. A total of 301 root canal-treated incisors and canines were restored. At repeat follow-up appointments, 291 restorations were still in function after a mean time of service of 7.13 ±2.11 years. Cumulative survival probability at 9 years was 96.0%. No parameter observed was found by log-rank test to have a statistically significant effect on survival rate.

Conclusions. Adhesive buildup with prefabricated fiber posts in anterior teeth is a reliable method of post-endodontic treatment in this given clinical protocol.