Comparison of Early Implant Failure Rates Between Subjects With and Without Orthodontic Treatment Before Dental Implantation

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The present study compared early dental implant failure rates between patients with and without orthodontic treatment before dental implantation. The data of adults who had undergone dental implantation between January 2007 and December 2016 were analyzed retrospectively. A total of 124 subjects with 255 implants were divided into a treatment group (46 subjects, 85 teeth) consisting of patients who had undergone implant surgery after orthodontic treatment and a control group of patients who had not undergone preimplant orthodontic treatment. Implants that failed before permanent crown fabrication were defined as failures. No significant differences in gender or age were found between the treatment group and controls. No significant differences were found in implant failure rates in either jaw between the treatment and control groups. However, the failure rate was still higher in the treatment group (14.81%) than in the control group (3.28%) for the maxilla. Results of this study demonstrate an increased implant failure rate only in the maxilla of patients who underwent orthodontic treatment before dental implantation, especially implant surgery combined with a sinus lift procedure. Further study with a larger sample size and longer follow-up period is necessary to confirm results of the present study and identify other confounding factors.

Key Words: dental implant, implant failure, orthodontic treatment, bone density

Introduction

Restoring a missing tooth or multiple teeth with dental implants is a highly predictable treatment.[1–3] To create ideal implant-supported prostheses, dental malalignment induced by a missing tooth usually necessitates orthodontic correction before dental implant placement can be performed. Bone density may decline after orthodontic therapy, and decreases in bone density can occur as early as 7 months after orthodontic treatment.[4–9] In addition, bone density changes are associated with the direction of tooth movement.[4,10] Bone density is associated with implant osteointegration time and failure rates,[11] and surgical protocols and loading schemes are also performed according to bone density.[12] With longer osteointegration periods, implant rates are expected to be higher in soft bone than in hard bone.

Results of our preliminary study[13] revealed that orthodontic treatment induced more changes in bone density of the maxilla than that of the mandible.[13] Greater changes in bone density occur in the maxilla than in the mandible because of greater bone remodeling activity in the maxilla.[5] In addition, the maxilla is weaker than the mandible, which induces higher levels of strain. This, in turn, results in more microcracks and microdamage to the maxilla when there is stress.[5] However, to the best of our knowledge, no published studies have focused on the effect of orthodontic treatment on early dental implant failure rates because of changes in bone density. We hypothesized that orthodontic treatment prior to dental implantation may be associated with early dental implant rates. Therefore, the present study aimed to compare dental implant failure rates between patients with and without orthodontic treatment before dental implantation.

Materials and Methods

Study subjects

This retrospective study analyzed the data of adults who had undergone dental implant treatment by the same surgeon in our department at Chang Gung Memorial Hospital between January 2007 and December 2016. The exclusion criteria for subjects were as follows: implant surgery performed in patients aged >50 years, patients with a systemic condition such as diabetes or osteoporosis, and patients who smoked or had a history of taking a medication, such as bisphosphonates, known to affect bone density. Further, the exclusion criteria for implant sites included sites that underwent ridge preservation or ridge augmentation before dental implant placement and that had severe trauma.[13]

Subjects were divided into two groups: a treatment group

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https://doi.org/10.1563/aaid-joi-D-17-00222

(group T) that had undergone orthodontic treatment within 2 months before implant placement (between January 2007 and December 2016) and a control group (group C) that had not undergone orthodontic therapy before implant surgery (between January 2011 and December 2016). However, if the implant site was not within the orthodontic treatment area, the implant site was placed in the control group (group C) rather than the treatment group (group T). For example, if orthodontic therapy was performed on only the upper arch, the implant site of the lower arch was included in group C.

Ethical considerations

This study was conducted in accordance with the Helsinki Declaration of 1975 as revised in 2000. The protocol was approved by the hospital institutional board (Chang Gung Memorial Hospital No. 201700042B0).

Surgical procedures

All patients received 2-staged implant therapy, including stage I and stage II surgeries. Orthodontic wires were removed before implant surgery in group T. The implants used were the 3i system (Osseotite or Certain Taper, Biomet 3i, Palm Beach Gardens, Fla). All procedures were performed after flap elevation under dental local anesthesia. Primary wound closure was used with resorbable suture. Postoperative antibiotics and analgesics were prescribed for 3 days (nongrafting cases) or 7 days (grafting cases and sinus lift cases). The sinus lift method used the crest approach with osteotome technique. The used grafts included autograft, allograft, and xenograft. The suture was removed after 2 weeks (Figure).

Table 1

Baseline characteristics of subjects*

	Group C (n = 78)	Group T (n = 46)	*P* value
Gender			.913
Female	33 (42.31%)	19 (41.30%)	
Male	45 (57.69%)	27 (58.70%)	
Age (y)	40.57 ± 7.18	39.30 ± 9.66	.407
Included implants	170	85	

*Group C indicates control group; group T, treatment group.

Table 2

Comparisons of all implants by group†

	Group C (n = 170)	Group T (n = 85)	*P* value
Location			.255
UA	10 (5.88%)	2 (2.35%)	
UP	18 (10.59%)	9 (10.59%)	
UM	33 (19.41%)	16 (18.82%)	
LA	0 (0%)	1 (1.18%)	
LP	18 (10.59%)	4 (4.71%)	
LM	91 (53.53%)	53 (62.35%)	
Extraction etiology			.093
Missing/space creation	97 (57.06%)	60 (70.59%)	
Periodontitis	24 (14.12%)	10 (11.76%)	
No periodontitis	49 (28.82%)	15 (17.65%)	
Stage I surgery			
Sinus lift	38 (22.35%)	16 (18.82%)	.516
Bone grafting	95 (55.88%)	46 (54.12%)	.789
Bone density			
D1	23 (13.53%)	6 (7.06%)	.024*
D2	17 (10%)	8 (9.41%)	
D3	67 (39.41%)	23 (27.06%)	
D4	63 (37.06%)	48 (56.47%)	
Non–soft bone (D1 + D2 + D3)	107 (62.94%)	37 (43.53%)	.003*
Soft bone (D4)	63 (37.06%)	48 (56.47%)	
Implant insertion torque			
<30 N/cm	25 (16.56%)	17 (27.87%)	.061
≥30 N/cm	126 (83.44%)	44 (72.13%)	
Timing, d‡			
Extraction (or missing) to stage I surgery	130.5 (72–271)	841.5 (519–1262)	<.001*
Duration between stage I and stage II surgery	188 (132–283)	155 (105.5–230)	.006*
Stage I surgery to prosthetic treatment finish	321 (241–391)	293 (213–435)	.467
Follow-up	1220 (948–1776)	1121 (586–2295)	.858
Survival§	166 (97.65%)	81 (95.29%)	.310
Failure	4 (2.35%)	4 (4.71%)	

†Group C indicates control group; group T, treatment group; UA, upper anterior teeth; UP, upper premolars; UM, upper molars; LA, lower anterior teeth; LP, lower premolars; LM, lower molars; D1, D2, D3, and D4, bone density accorded to Misch's classification.

‡Durations are presented as medians and interquartile ranges.

§Assessed using Fisher exact test.

*Significant difference ($P < .05$).

TABLE 3

Comparisons of maxillary implants by group†

	Group C (n = 61)	Group T (n = 27)	*P* value
Location			.525
UA	10 (16.39%)	2 (7.41%)	
UP	18 (29.51%)	9 (33.33%)	
UM	33 (54.10%)	16 (59.26%)	
Extraction etiology			.330
Missing/space creation	28 (45.9%)	17 (62.96%)	
Periodontitis	12 (19.67%)	4 (14.81%)	
No periodontitis	21 (34.43%)	6 (22.22%)	
Stage I surgery			
Sinus lift	38 (62.30%)	16 (59.26%)	.787
Bone grafting	39 (63.93%)	16 (59.26%)	.676
Bone density			
D1	0 (0%)	0 (0%)	.001*
D2	2 (3.28%)	0 (0%)	
D3	28 (45.9%)	3 (11.11%)	
D4	31 (50.82%)	24 (88.89%)	
Non–soft bone (D1 + D2 + D3)	30 (49.18%)	3 (11.11%)	.001*
Soft bone (D4)	31 (50.82%)	24 (88.89%)	
Implant insertion torque			
<30 N/cm	14 (25%)	11 (52.38%)	.022*
≥30 N/cm	42 (75%)	10 (47.62%)	
Timing, d‡			
Extraction (or missing) to stage I surgery	147 (78–373)	738 (424–1379)	.004*
Duration between stage I and stage II surgery	292 (246–337)	250 (177–315)	.080
Stage I surgery to prosthetic treatment finish	390 (336–495)	387 (350–456)	.920
Follow-up	1077 (948–1636)	753.5 (81.5–1572)	.062
Survival§	59 (96.72%)	23 (85.19%)	.069
Failure	2 (3.28%)	4 (14.81%)	

†Group C indicates control group; group T, treatment group; UA, upper anterior teeth; UP, upper premolars; UM, upper molars; D1, D2, D3, and D4, bone density accorded to Misch's classification.

‡Durations are presented as medians and interquartile ranges.

§Assessed using Fisher exact test.

*Significant difference ($P < .05$).

Data collection

Patients' baseline demographic and clinical data were recorded, including sex, age and along with the other parameters for the implant sites were recorded. The implant sites were divided into either the maxillary area or mandibular area. Detailed locations also were analyzed as follows: upper anterior (UA), upper premolar (UP), upper molar (UM), lower anterior (LA), lower premolar (LP), and lower molar (LM). The site conditions before, during, and after implant placement surgery (stage I surgery) were also included. Classification of bone density was carried out accorded to Misch's classification system.[14–16] Soft bone was defined as D4 bone, and the other bone types were included in the non–soft bone group. Primary stability of the dental implant was measured using the implant insertion torque (N/cm) as reference, and 30 N/cm was established as the cutoff point. In addition, the timing, including stage I, stage II, and prosthetic treatment finish, were recorded. Implants that failed before permanent crown fabrication were defined as failure cases.

Statistical analysis

Categorical variables are presented as counts and percentages, and chi-square or Fisher exact test were performed to compare differences between groups T and C, as appropriate, as each tooth was independent in this study. Age is presented as mean ± SD (standard deviation), and an independent *t* test was performed for group comparisons. Duration between two timepoints is presented as medians and interquartile ranges, and the Mann-Whitney *U* test was performed to compare differences between groups T and C. Statistical analyses were performed using IBM SPSS statistical software, version 22 for Windows (IBM Corp, Armonk, NY), and a two-tailed *P* value of <.05 indicated statistical significance.

RESULTS

Baseline characteristics of subjects

A total of 124 subjects (52 women and 72 men, with a mean age of 40.1 years) with 255 implants were included in this study, and 46 subjects with 85 implants were included in the treatment group (group T). No significant differences were found between groups T and C in gender or age (both $P > .05$; Table 1).

Comparisons of all implants between treatment and control groups

A total of 255 implants were included in this study, with 85 implants in group T and 170 teeth in group C. The median

Table 4

Comparisons of mandibular implants by group†

	Group C (n = 109)	Group T (n = 58)	*P* value
Location‡			.069
LA	0 (0%)	1 (1.72%)	
LP	18 (16.51%)	4 (6.90%)	
LM	91 (83.49%)	53 (91.38%)	
Extraction etiology			.294
Missing/space creation	69 (63.3%)	43 (74.14%)	
Periodontitis	12 (11.01%)	6 (10.34%)	
Nonperiodontitis	28 (25.69%)	9 (15.52%)	
Stage I surgery			
Bone grafting	56 (51.38%)	30 (51.72%)	.966
Bone density			
D1	23 (21.1%)	6 (10.34%)	.244
D2	15 (13.76%)	8 (13.79%)	
D3	39 (35.78%)	20 (34.48%)	
D4	32 (29.36%)	24 (41.38%)	
Non–soft bone (D1 + D2 + D3)	77 (70.64%)	34 (58.62%)	.117
Soft bone (D4)	32 (29.36%)	24 (41.38%)	
Implant insertion torque			
<30 N/cm	11 (11.58%)	6 (15%)	.584
≥30 N/cm	84 (88.42%)	34 (85%)	
Timing, d‡			
Extraction (or missing) to stage I surgery	130 (69–60)	859.5 (537–1242)	<.001*
Duration between stage I and stage II surgery	155 (119–186)	134 (97–181)	.070
Stage I surgery to prosthetic treatment finish	271 (207–334)	259 (194–413)	.741
Follow-up	1220 (948–1794)	1624 (756–2414)	.212
Survival§	107 (98.17%)	58 (100%)	.544
Failure	2 (1.83%)	0 (0%)	

†Group C indicates control group; group T, treatment group; LA, lower anterior teeth; LP, lower premolars; LM, lower molars; D1, D2, D3, and D4, bone density accorded to Misch's classification.

‡Durations are presented as medians and interquartile ranges.

§Assessed with Fisher's exact test.

*Significant difference ($P < .05$).

duration from extraction to Stage I was significantly higher in group T than in group C (841.5 vs 130.5 days, respectively; $P < .001$), but the duration from stage I to stage II was significantly higher in group C than group T (188 vs 155 days, respectively; $P = .006$). Bone density was significantly different between groups T and C; a higher percentage of group C patients had non–soft bone than group T patients ($P = .003$). No significant differences in any other parameters were found between the two groups (Table 2).

Comparisons of maxillary and mandibular implants between treatment and control groups

In the maxilla, group T had 27 implants and group C had 61 implants. The median duration from extraction to stage I was significantly higher in group T than in group C (738 vs 147 days, respectively; $P = .004$). Bone density was significantly different between groups, with a higher percentage of non–soft bone (density of D1, D2, and D3) demonstrated in group C than in group T (both $P = .001$). Implant insertion torque <30 N/cm was higher in group T than in group C (58.38% vs 25%, respectively; $P = .022$; Table 3).

In the mandible, group T had 58 implants and the control group had 109 implants. The median duration from extraction to stage I was significantly higher in group T than in group C (859.5 vs 130 days, respectively; $P < .001$). No significant differences were found in any other parameters between groups T and C (all $P > .05$; Table 4).

Discussion

No significant differences in failure rates for maxilla implants were found between the treatment group receiving preimplant orthodontic treatment and the control group, which did not receive orthodontic treatment; however, the implant failure rate in the treatment group was higher than that in the control group. For mandible implants, no significant differences in any parameter were found between the two groups.

The main risk factors reported previously for early implant failure included smoking, shorter implant, implant inserted in the posterior area of the jaw, implants placed in small-volume bone or soft bone, and implants placed in the maxilla.[17,18] Low implant insertion torque and implant insertion into soft bone were associated with an increased implant failure rate in the maxilla.[18] In the present study, the group receiving orthodontic treatment had a higher percentage of soft bone and implant insertion torque <30 N/cm than found in controls; therefore, soft bone and higher implant insertion torque may be important contributing factors to the higher implant failure rate in the treatment group.[13] In the present study, 4 implant failures occurred in treatment group patients. All 4 implant sites

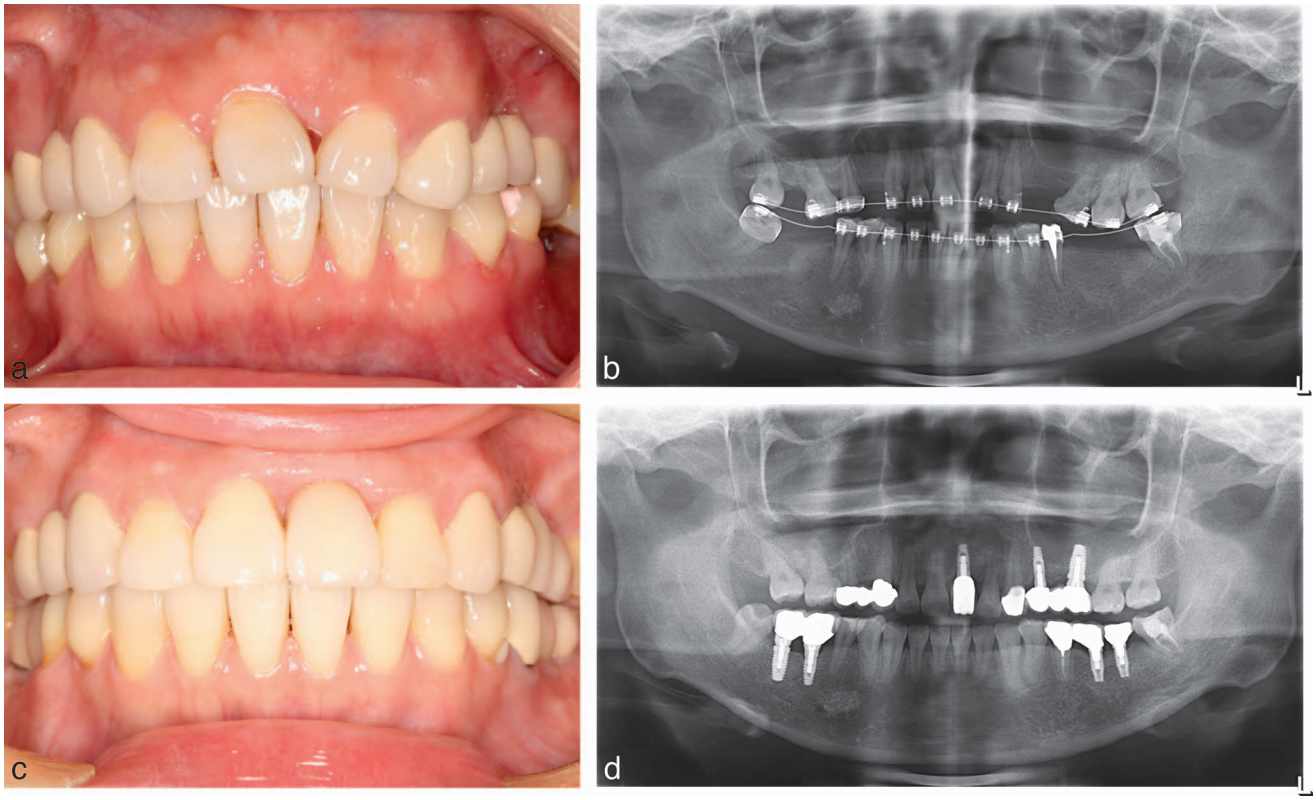

Figure. A young female patient in group T is shown. (a) The dentition malalignment induced esthetic and functional problems. (b) The orthodontic treatment was performed before dental implant therapy. (c) The esthetic and occlusion were built up after prosthetic treatment. (d) The bone level was stable after functional loading for 2 years.

were placed in the first molar area; in addition, a sinus lift using an osteotome technique was performed in all 4 cases. Three poor osteointegration cases and one sinus infection were included in the above failures. Previous studies reported a survival rate for the osteotome technique ranging from 85.1% to 100%, which was comparable to that found in traditional implantology.[19–21] The survival rates of sinus lift (total teeth: 49/54 = 90.74%) in the present study were similar to the rates shown above. However, the osteotome technique in the treatment and control groups had survival rates of 75% (12/16) and 97.4% (37/38), respectively. The difference may be associated with inadequate volume and soft bone quality in the upper first molar sites of the treatment group, which was induced by bone density change in the maxilla derived from orthodontic treatment.

Shifts in the balance between bone formation and bone resorption are influenced by many factors, including aging, postmenopausal status, chronic inflammation, and a number of other factors. To avoid such factors in this study, we excluded subjects who were older than age 50 years, which should decrease the confounding effects of aging and menopause on bone density.[22,23]

Bone density changes observed during orthodontic treatment persist until the orthodontic treatment has been completed. For this reason, more time may be needed for osteointegration before functional loading.[12] However, no study has shown precisely how long bone density improvement will take.[6] Therefore, delaying implant placement until the bone density recovers is not suggested.[13]

A major limitation of this study was the small sample size, especially the number of upper teeth in the treatment group. Any space in the maxilla can usually be closed during orthodontic treatment; the treatment group actually had fewer maxillary teeth than mandibular teeth. Therefore, further investigation of the effects of other confounding factors based on a larger sample size and clinical trial study is necessary.

Conclusion

No significant differences were found in failure rates of either jaw between patients receiving orthodontic treatment prior to implant surgery and controls not receiving preimplant orthodontic treatment. However, the implant failure rate in the maxilla was higher for patients receiving orthodontic treatment than for those who did not receive preimplant treatment, especially in patients receiving implant surgery combined with sinus lift. Additional study with a larger sample size and longer follow-up period is necessary to confirm the results of the present study and to identify other confounding factors.

Abbreviations

LA: lower anterior teeth
LM: lower molars

LP: lower premolars
UA: upper anterior teeth
UM: upper molars
UP: upper premolars

Note

The authors declare no conflict of interest.

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