Factors Influencing the Outcome of Root-Resection Therapy in Molars: A 10-Year Retrospective Study

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Background: Root resection is one treatment option for preserving molars with furcation involvement. This study evaluated the prognosis of root-resection therapy retrospectively and examined the factors influencing the survival rate of resected molars.

Methods: Root-resection therapy was performed on 691 molars in 579 patients. The associated factors were examined from 342 of 402 molars that had been followed up for >1 year. Survival analysis was used to statistically analyze the factors.

Results: Over the past 10 years, 102 of 342 cases (29.8%) failed. The factors were classified into four groups and analyzed to determine their influence on the survival rate of the resected molars. Regarding the resection-related factors, the molars resected because of periodontal problems had a higher survival rate than those resected because of non-periodontal problems (tooth fracture, dental caries, and endodontic problems; $P = 0.0097$). Patient- and tooth-related factors had no effect on the survival rates. Among the site-related factors, only the amount of bone support of the remaining roots at the time of surgery had a significant effect on the survival rate in the group of molars with periodontal problems ($P = 0.0269$).

Conclusions: Root resection to treat periodontal problems had a better prognosis than for non-periodontal problems. To achieve a good result, it was important that the remaining roots had >50% bone support. This guideline may help to improve the predictability of root-resection therapy. *J Periodontol 2009;80:32-40.*

KEY WORDS

Furcation defects; molar; periodontitis; risk factors.

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Root resection is the process by which one or more of the roots of a tooth are removed at the level of the furcation while leaving the crown and remaining roots in function.[1] Farrar[2] introduced this root-resection procedure, which has been used to treat Class II and III furcation-involved molars. Through root-resection therapy, furcation-involved molars can be converted to non-furcated single-root teeth and provide a favorable environment for oral hygiene for patients and clinicians.

The prognosis of root resection has been well-documented. Some investigators[3,4] reported that root-resected molars had >90% survival rate, whereas other investigators[5-8] reported that ~30% of resected molars failed over a 10-year period. Some investigators compared the prognosis of root-resection therapy to that of implant therapy. Kinsel et al.[9] reviewed the result of root-resection therapy and single implants in molar regions. They reported a 15.9% failure rate for root-resection therapy, whereas single implants showed a 3.6% failure rate. They stated that root-resection therapy had poor long-term results unless a high level of expertise was available in all applicable disciplines. In contrast, Fugazzotto[10] reported 15-year cumulative success rates of 96.8% for root-resected molars and 97.0% for molar implants. He concluded that molar root–resection therapy and implant therapy had a high degree of functional success.

doi: 10.1902/jop.2009.080316

Because implant therapy is popular, the clinical significance of root-resection therapy needs to be discussed further. Basaraba[11] proposed the following indications for root-resection therapy: teeth with periodontal problems, endodontic problems, root fractures, and prosthetic problems. In a recent article, Minsk and Polson[12] suggested that root resection can be a valuable procedure when the tooth in question has a very high strategic value or when there are specific problems that cannot be solved by other therapeutic approaches. Teeth in proximity to anatomic landmarks, such as the maxillary sinus and inferior alveolar canal, can be treated safely by root-resection therapy. In addition, resected molars can be used for alveolar bone augmentation by orthodontic movement.

The most important factors for the prognosis of root-resection therapy have been suggested.[3-8,12,13] The following should be considered when deciding which root should be retained: the amount of supporting tissue around the roots, the root and root canal anatomy in relation to the endodontic treatment, the periapical condition, and the mobility of each separated root.[13] Molars with minimal supporting bone or deep osseous craters in the furcation area are poor candidates for root-resection therapy as a result of the recurrent periodontal breakdown of resected molars.[5] However, there are few reports showing the factors that actually influence the survival rate of resected molars.[8]

This study examined the survival rates of resected molars retrospectively for 10 years and analyzed the factors affecting the survival rate.

MATERIALS AND METHODS

Patient Population

From December 1994 to March 2006, 579 Korean patients (384 males and 195 females; mean age: 50.8 ± 11.4 years [range, 13 to 77 years]) received root-resection therapy on 691 molars at the Institute of Oral Health Science, Samsung Medical Center. The patients who underwent root-resection therapy because of periodontal problems (357 patients and 458 molars) had moderate to severe chronic periodontitis. The related factors were analyzed from the 342 cases (276 patients) among 402 molars (330 patients) that had been followed up for >1 year. The mean follow-up period was 55.10 ± 31.96 months. Sixty cases (54 patients) were excluded because of missing records and radiographs. Table 1 shows the patient distribution according to age, gender, and smoking. Smokers were defined as those who smoked >10 cigarettes a day.[14,15] People who changed smoking status during the study period were excluded from consideration. The resections were carried out for the following reasons: periodontal problems, endodontic problems, dental caries, and tooth fractures. In this study, root-resection therapy included root resection (229 cases), hemisection (67 cases), and bicuspidization (46 cases) The resections were performed by periodontists (329 cases), endodontists (12 cases), and a prosthodontist (one case). Samsung Medical Center Institutional Review Board approved this retrospective study. All subjects were informed about the treatment procedures and provided oral informed consent before surgery.

Table 1.

Distribution of the Samples According to Age, Gender, and Smoking

Age (years)	n	Gender		Smoking	
		Male	Female	Yes	No
10 to 19	1	0	1	0	1
20 to 29	6	3	3	2	4
30 to 39	34	21	13	8	26
40 to 49	119	80	39	51	68
50 to 59	116	83	33	45	71
60 to 69	58	32	26	9	49
>70	8	6	2	2	6
Total	342	225	117	117	225

Clinical Examinations and Radiographs

A retrospective review of all cases was accomplished using the dental charts and radiographs. Data were collected on the type of prosthetic abutment,[3] type of opposing dentition, amount of bone support of the remaining roots, classification of furcation involvement, presence of periapical lesions, endodontic treatment status, and number of teeth remaining. The amount of bone support of remaining roots was measured from the periapical radiographs taken prior to the resection on the day of surgery. The periapical radiographs were obtained with the film holding device† and long-cone paralleling technique. One examiner (SYP), who did not perform root-resection therapy, evaluated all of the radiographs. The amount of bone support was determined by the distance from the most coronal bone level to the root apex/the distance from 2 mm below the proximal cemento-enamel junction to the root apex. Information on the reasons for the resection, practitioner (experienced [>5 years clinical experience] or non-experienced [<5 years]), and the extracted roots was recorded. Post-surgical prostheses were evaluated. After the root resection, 201

† XCP alignment instrument, Dentsply Rinn, Elgin, IL.

patients (254 molars) had 3- or 6-month regular supportive maintenance treatment (SPT) by dentists or hygienists. SPT consisted of ultrasonic subgingival instrumentation and oral hygiene instruction.

Failure Criteria

The failures were evaluated using the following modified criteria reported by Langer et al.:[5] teeth with >50% loss of the remaining alveolar bone present after the first six postoperative months (radiographically determined) or progressive tooth mobility were diagnosed as hopeless;[3] teeth with unrecovered periapical lesion (>1.5 mm apical radiolucency);[6] teeth with a root fracture; unrestorable teeth with secondary caries; and others (e.g., strategic extraction for prosthesis or strategic extraction for space gaining in orthodontic treatment).

The mean follow-up period was 55.10 ± 31.96 months. All failures were divided into two groups: early group (failure before 55 months) and late group (failure after 55 months).

Statistical Analyses

All statistical analyses were carried out using a computer program.‡ The failure rates of the resected molars were tested using the Fisher exact test and an exact binomial test with a Bonferroni correction. The statistical techniques for survival analysis were carried out to analyze the survival of the root-resected molars over time and to identify the factors that can affect the survival of the resected molars.[8,16] The Kaplan-Meier estimation method was used for survival analysis. The Cox proportional hazard regression test was used to determine whether age and the remaining dentition had an effect on the survival time. The other factors were analyzed using the Breslow test, which compared the survival curves with time. A P value <0.05 was considered significant.

RESULTS

Distribution of Resected Molars

In this study, 140 maxillary first molars, 118 mandibular first molars, 46 maxillary second molars, and 38 mandibular second molars were examined. Table 2 shows the periodontal, endodontic, and prosthodontic status at the time of the resection. Sixty-eight percent of molars had roots remaining with >50% bone support. Class II or III furcation involvement was observed in 80% of the molars, and 55% of the molars had Class III furcation involvement at the resection. Vital resections were performed in 74 cases, and 83 molars had periapical radiolucencies at the time of root resection. Of the 342 molars, 283 (82.7%) were single abutments, 39 were terminal abutments of a fixed bridge, 18 were intermediate abutments of a fixed bridge, and only two were abutments of a removable partial denture (RPD) at the time of the surgery. Most of the opposing dentition was natural teeth. The mean number of remaining teeth at root resection was 26.6 ± 3.6. After the resection, most of the molars were restored by single crowns or short-unit fixed bridges (single crowns, n = 178; fixed bridges [up to three units], n = 144; fixed bridges [more than three units] n = 17; abutments of RPD, n = 3).

Failure Rates of Resected Molars

Over a 10-year period, 102 of 342 teeth (29.8%) failed (Table 3). Among the failures, periodontal failures (50%) were observed most frequently. The mandibular molars had higher failure rates than the maxillary molars, but the difference was not significant. The pattern of failure was different for each arch. The teeth that failed because of a root fracture and dental caries were more common in the mandible than in the maxilla (P = 0.0192 and P = 0.0117, respectively; Fisher exact test). Failed molars as a result of periodontal problems were more common in the maxilla than in the mandible (P=0.0489; Fisher exact test).

Most cases were single-root resections (Table 4). In the maxilla, a palatal root resection had a higher failure rate than the others, but this was not significant. Teeth that had undergone a disto-buccal root resection or palatal root resection had more early failures than the other teeth in the maxilla. In the mandible, a disto-lingual root resection or a resection of both distal roots (distal root and disto-lingual root) in three-rooted molars had a higher failure rate than the other teeth, although this finding was not significant because of the small sample size. Teeth that had undergone a distal or a mesial root resection in the mandible had more early periodontal failures than bicuspidizations. The distal root–resected mandibular molars had more root fractures than the other molars in the mandible (P=0.004; exact binomial test with a Bonferroni correction).

Among 342 root resections, 251 molars (73.3%) received root-resection therapy for periodontal reasons (Table 5). The percentage of periodontal failures was 15.9% (40/251) among the molars that underwent root-resection therapy for periodontal reasons. The molars resected because of tooth fractures and endodontic problems had higher failure rates than the molars resected because of periodontal problems (35.6%, 37.9%, and 28.3%, respectively). In the molars that were resected because of tooth fractures, early failures were seven times more likely than late failures, and 57% of these early failures were periodontal failures.

Evaluation of Factors Affecting Survival Rates

The factors that could have affected the survival rate were categorized into four groups: resection-, patient-,

‡ SAS, Chicago, IL.

Table 2.

Periodontal, Endodontic, and Prosthodontic Status of the Resected Molars at the Time of Root Resection

Periodontal Status				Endodontic Status						Prosthodontic Status			
Bone Support of Remaining Roots		Furcation Involvement		Endodontic Treatment		Dental Caries		Periapical Lesion		Type of Abutment		Opposing Dentition	
>2/3	25	No	44	Filled	266	Yes	43	Yes	83	Single	283	Natural teeth	301
1/2∼2/3	209	Class I	23	Temp filled	2	No	299	No	259	BI	18	Implants	20
1/3∼1/2	108	Class II	87	Vital	74					BT	39	Denture	14
		Class III	188							RPD abutment	2	Edentulism	7
Total	342	Total	342	Total	342	Total	342	Total	342	Total	342	Total	342

BI = intermediate abutment of fixed bridge; BT = terminal abutment of fixed bridge.

Table 3.

Reasons for Failure According to Molar Location

Distribution of Cases (n)	Failure Reason (n [%])						Failure Rate (%)
	Periodontal*	Fracture†	Endodontic	Caries‡	Others	Total	
Mx first molar (140)	24 (68.6)§	2 (5.7)	4 (11.4)	1 (2.9)	4 (11.4)	35 (100)	25.0
Mx second molar (46)	9 (69.2)‖	2 (15.4)	1 (7.7)	0 (0)	1 (7.7)	13 (100)	28.3
Mn first molar (118)	14 (35.0)	9 (22.5)	4 (10.0)	7 (17.5)	6 (15.0)	40 (100)	33.9
Mn second molar (38)	4 (28.6)	6 (42.9)	0 (0)	3 (21.4)	1 (7.1)	14 (100)	36.8
Total (342)	51 (50.0)¶	19 (18.6)#	9 (8.8)	11 (10.8)	12 (11.8)	102 (100)	29.8

Mx = maxillary; Mn = mandibular.
Statistical significance of the failure rates between maxillary molars and mandibular molars was tested by the Fisher exact test (statistical significance level, P <0.05).
* Statistically significant difference between maxillary molars and mandibular molars; P = 0.0489.
† Statistically significant difference between maxillary molars and mandibular molars; P = 0.0192.
‡ Statistically significant difference between maxillary molars and mandibular molars; P = 0.0117.
Statistical significance of the failure rates according to the reasons for the failure was tested using the exact binomial test with a Bonferroni correction (α = 0.05/5 = 0.01).
§ Statistically significant difference in the maxillary first molars; P = 0.0009.
‖ Statistically significant difference in the maxillary second molars; P <0.0001.
¶ Statistically significant difference among the total number of failure reasons; P <0.0001.
# Statistically significant difference among the total number of failure reasons; P = 0.0028.

tooth-, and site-related factors (Table 6). These factors were analyzed using survival analysis. Because the resected molars had different follow-up times, survival analysis was considered the appropriate statistical analysis. With regard to the resection-related factors, the molars that were resected because of periodontal disease had a higher survival rate than the molars that were resected because of non-periodontal problems, such as tooth fractures, endodontic problems, and dental caries (P= 0.0097; Breslow test). Root resections by an experienced practitioner resulted in a higher survival rate than resections by an inexperienced practitioner, but the difference was not significant. The patient-related factors, such as gender, age, smoking, and remaining dentition, did not influence the survival rates of all resected molars. Nonsmokers had a higher survival rate than smokers, but the difference was not statistically significant. Molars maintained by SPT also showed a higher survival rate than the molars without maintenance treatment, although the difference was not significant. The tooth-related factors, including the location of the resected molars and roots, type of prosthetic abutment, opposing dentition, and postoperative prosthesis, had no effect on the survival rates in all resected molars. Molars used as intermediate abutments of a fixed bridge had a higher survival rate than those used as terminal abutments of a fixed bridge, abutments of an RPD, and

Table 4.

Reasons for Failure and the Failure Rates According to Location of the Resected Roots

Location	Resected Roots	n	Failure Reason					Total	Failure Rate (%)
			Periodontal	Fracture	Endodontic	Caries	Other		
Maxilla	MB	65	8* (4/4)	2 (2/0)	2 (0/2)	1 (0/1)	2 (2/0)	15 (8/7)	23.1
	MB, DB	13	4 (2/2)					4 (2/2)	30.8
	DB	70	11† (7/4)		2 (2/0)		1 (1/0)	14 (10/4)	20.0
	D	3		1 (1/0)				1 (1/0)	33.3
	P	35	10‡ (6/4)	1 (0/1)	1 (1/0)		2 (2/0)	14 (9/5)	40.0
Mandible	M	45	6 (6/0)	1 (1/0)	1 (0/1)	6 (2/4)	3 (2/1)	17 (11/6)	37.8
	MB	1						0	0
	ML	1						0	0
	D	45	6 (5/1)	9§ (4/5)				15 (9/6)	33.3
	D, DL	3			1 (0/1)		1 (0/1)	2 (0/2)	66.7
	DL	10		2 (1/1)		1 (0/1)	2 (2/0)	5 (3/2)	50.0
	DB	3						0	0
	NO	36	6 (2/4)	3 (3/0)	2 (1/1)	3 (3/0)	1 (1/0)	15 (10/5)	32.6
Total		342	51 (32/19)	19 (12/7)	9 (4/5)	11 (5/6)	12 (10/2)	102 (63/39)	29.8

(/) = (number of early failures/number of late failures); MB = mesio-buccal root; DB = disto-buccal root; D = distal root; P = palatal root; M = mesial root; ML = mesio-lingual root; DL = disto-lingual root; NO = bicuspidized molars.
Statistical significance of the failure rates according to the reasons for failure was tested using an exact binomial test with a Bonferroni correction ($\alpha = 0.05/5 = 0.01$).
* Statistically significant difference in MB resected molars; $P = 0.004$.
† Statistically significant difference in DB resected molars; $P = 0.0006$.
‡ Statistically significant difference in P resected molars; $P = 0.0003$.
§ Statistically significant difference among the mandibular resected molars; $P = 0.004$.

single abutments; the difference was near the cutoff point for statistical significance ($P = 0.0679$; Breslow test). Among the site-related factors, molars with root canal treatment and molars without dental caries or periapical lesions prior to resection had higher survival rates, but the difference was not significant. Only the amount of bone support of the remaining roots at the time of surgery had a significant effect on the survival rate in the group in which the root-resection therapy had been carried out because of periodontal problems ($P = 0.0269$; Breslow test). The molars with >50% bone support had a higher survival rate than those with <50%.

DISCUSSION

Root-resection therapy is a treatment option for molars with periodontal, endodontic, restorative, or prosthetic problems. Because root resection is very technique sensitive and complex, proper case selection is essential.[17] The prognosis of root resection has been well-documented in previous studies,[3-8,12,13] but the factors that affect the survival rate of resected molars have not been discussed in depth. This study examined the factors that could influence the survival rate of resected molars.

Langer et al.[5] reported a 38% failure rate for the resected molars over a 10-year period; 26% of failures were due to periodontal problems. Bulher[6] reported that 32.1% of resected molars failed, and 44% of failures were related to periodontal problems. Blomlof et al.[8] showed similar results, in that 32% of molars failed over a 10-year period; 80% of the failed molars were lost because of periodontal or endodontic-periodontal lesions. They revealed that the patient sample was prone to periodontitis, which resulted in a large number of periodontal failures. According to the standardized reports on root resection of Buhler,[18] 89% of root-resected teeth survived over a 7-year period. In this study, the failure rate of all molars over a 10-year period was 29.8%, which is similar to previous studies.[5-8] However, Carnevale et al.[4] reported a 6.9% failure rate over a 10-year period, which was lower than this study. This difference might be because the inclusion criteria and maintenance program in Carnevale et al.'s study were more strict. Although they performed root-resection therapy mostly on molars with Class II furcation involvement, the molars in our study had more severe furcation involvement and more periodontal destruction.

With regard to the reasons for failure in our study, the maxillary molars had more periodontal failures, and the mandibular molars had more root fractures and dental caries. Similarly, Langer et al.[5] reported that 54% of failed maxillary molars failed as a result of periodontal reasons, and 60% of failed mandibular

Table 5.

Reasons for Failure According to Reason for Resection

Resection Reason (n)	Failure Reasons						Failure Rate (%)
	Periodontal	Fracture	Endodontic	Caries	Other	Total	
Periodontal problem (251)	40* (22/18)	14 (9/5)	5† (2/3)	6 (3/3)	7 (5/2)	72 (41/31)	28.3
Tooth fracture (45)	9‡ (8/1)	1 (1/0)	2 (2/0)	3 (2/1)	1 (1/0)	16 (14/2)	35.6
Endodontic problem (29)	1 (1/0)	3 (2/1)	1 (0/1)	2 (0/2)	3 (3/0)	10 (6/4)	37.9
Dental caries (17)	1 (1/0)	1 (0/1)	1 (0/1)	0 (0/0)	1 (1/0)	4 (2/2)	23.5
Total (342)	51 (32/19)	19 (12/7)	9 (4/5)	11 (5/6)	12 (10/2)	102 (63/39)	29.8

(/) = (number of early failures/number of late failures).
Statistical significance of the failure rates according to the reasons for the failure was tested using an exact binomial test with a Bonferroni correction (α = 0.05/5 = 0.01).
* Statistically significant difference in the molars resected because of periodontal problems; $P<0.0001$.
† Statistically significant difference in the molars resected because of periodontal problems; $P = 0.005$.
‡ Statistically significant difference in the molars resected because of tooth fracture; $P = 0.001$.

Table 6.

Survival Analysis of Resected Molars According to Resection-, Patient-, Tooth-, and Site-Related Factors (*P* value)

Factors		All Resected Molars	Resected Molars With Periodontal Problems
Resection-related factors	Bicuspidization versus resection	0.4063	0.5449
	Resection reason (periodontal versus non-periodontal)	0.0097*	–
	Resection reason versus failure reason	0.2651	–
	Practitioner (experienced versus inexperienced)	0.1926	0.4429
Patient-related factors	Gender	0.7899	0.9165
	Age	0.1056	0.1860
	Smoking	0.2098	0.4988
	Remaining dentition	0.3733	0.4102
	SPT	0.3586	0.5579
Tooth-related factors	Resected tooth	0.5238	0.3665
	Resected roots	0.4174	0.6231
	Type of abutment	0.0679	0.0654
	Opposing dentition	0.4102	0.7631
	Postoperative prosthesis	0.4438	0.1825
Site-related factors	Bone support (>1/2 versus <1/2)	0.1620	0.0269*
	Furcation involvement	0.9192	0.8602
	Preoperative endodontic treatment	0.6751	0.2941
	Preoperative periapical lesion	0.6816	0.1342
	Preoperative dental caries	0.8642	0.8059

– = not applicable.
For survival analysis, Kaplan-Meier estimation method was used. The Cox proportional hazard regression test was used to determine whether age and the remaining dentition have an effect on the survival time. The other factors were tested using the Breslow test (statistical significance level, $P<0.05$).
* Statistically significant.

molars had a root fracture. According to Newell,[19] there were more failures in the maxilla than in the mandible because hidden roots/lips and ledges were not readily observed in the radiographs of the maxilla. Hamp et al.[13] also reported difficulties with maxillary molar root resection because of unfavorable access and the relationship with the neighboring teeth. Majzoub and Kon[20] reported that 86% of disto-buccal root–resected maxillary first molars experienced a violation of the biologic width, and only 6% of resected molars had a topography that was easily amenable to periodontal maintenance and prosthetic reconstruction. When performing root resection of maxillary molars, care should be taken not to overlook the furcal concavities and make a favorable environment for oral hygiene. After the resection, regular maintenance treatment, consisting of subgingival instrumentation, might be needed for the resected molars to prevent periodontal disease.[21] Although statistical significance was not demonstrated in this study, molars with maintenance treatment seemed to have a higher survival rate than those without maintenance treatment.

Clinical prediction of the long-term prognosis is important for avoiding additional treatment. This can help to prevent unnecessary costs and build a better rapport between the patients and clinicians. A method for determining the precise prognosis of periodontally diseased teeth was reported in various studies. McGuire[22] evaluated the traditional clinical factors known to affect the prognosis and concluded that some of the factors actually had no effect on tooth loss. Blomlof et al.[8] evaluated the prognosis of resected molars and reported that radiographic attachment loss, the number of teeth remaining, and smoking affected the survival rate of root-resected molars. However, there are insufficient reports on the factors that affect the outcomes of resected molars.

The survival rate of resected molars might be influenced by a variety of factors. Lang and Tonetti[23] suggested that an evaluation of the risk factors for periodontal disease progression was required at the patient, tooth, and site level. They suggested that the three levels of risk assessment represented a logical sequence for the clinical evaluation to be performed before rendering treatment during maintenance. The factors in our study were categorized into four groups: resection-, patient-, tooth-, and site-related factors.

The resection-related factors were analyzed. Molars that underwent root resection because of periodontal problems had a higher survival rate than those resected because of non-periodontal problems. Root-resection therapy for molars with periodontal problems was based on the periodontal pathology and could obtain a good prognosis. Root-resection therapy can remove the deposited periodontal bacteria and calculi as well as unfavorable anatomic features, which can act as a future bacteria reservoir. In addition, bone defects, such as hemiseptal bone defects and deep infrabony defects, can be resolved by healing after removing the involved roots, and a positive architecture can be achieved. Root-resection therapy might be a meaningful treatment option for saving periodontally diseased molars.

The patient-related factors, such as gender, age, smoking, SPT, and remaining dentition, had no effect on the prognosis. Smoking was reported to be a major risk factor for the prognosis of periodontally diseased teeth.[24,25] Furthermore, long-term studies[15,26] suggested that smoking is associated with the recurrence of periodontitis during periodontal maintenance. The effect seemed to be dose dependent, with heavy smokers (>10 cigarettes/day) showing higher levels of disease progression. Although the current study failed to show a relationship between smoking and the survival rate of the resected molars, smoking causes impaired healing after surgery and during the maintenance period,[27] and smoking cessation still plays an important role in periodontal health.

The tooth-related factors, such as molar location, resected roots, type of prosthetic abutment, opposing dentition, and postoperative prosthesis, did not affect the survival rates. Resected molars used as intermediate abutments of a fixed bridge had a higher survival rate, which was near the cutoff point for statistical significance. This might be because the occlusal loads on the intermediate abutment are smaller than on terminal abutments and single abutments. Consideration of occlusal loads is significant for the long-term survival of the prosthesis, and biomechanical failures such as root fractures were frequently reported in resected molars.[5] In this study, mandibular molars had more root fractures than maxillary molars, and all failed mandibular second molars had a distal root resection and single crown restoration without splinting. Because it was reported that mandibular second molars have the maximal bite force,[28,29] splinting with mesial teeth could be recommended to minimize the occlusal loads. In three-dimensional finite elementary analysis, splinting with mesial teeth resulted in intermediate stress concentrations compared to a single crown.[30] The restoration of resected molars should take into account the distribution of occlusal loads, and the remaining roots should carry the lightest loads possible.[31]

Site-related factors, according to the endodontic and periodontic status of the molars, were analyzed. The endodontic status of molars had no effect on the survival rates. The bone support of the remaining roots at the time of surgery affected the survival rate of molars with periodontal problems. Previous studies also reported the significance of the bone support of teeth. Nieri et al.[32] reported that the initial bone level was the most significant prognostic factor. Recently, Dannewitz et al.[33] reported that the baseline bone loss had an adverse effect on the retention time of molars. Muzzi et al.[34] suggested that the probability of tooth loss increased with a decreasing residual amount of supporting bone. The amount of bone support has been considered an important factor for the retention of teeth; however, the critical level of bone support for the survival of resected molars was not identified. In this study, when a root resection was carried out to resolve the periodontal problems, molars with bone support >50% of the remaining roots at the time of the root resection showed a significantly higher survival rate than those with <50% bone support.

CONCLUSIONS

Root-resection therapy is still a valid treatment option for molars with furcation involvement. Root resection to treat periodontal problems showed a better prognosis than root resection performed for non-periodontal purposes. To achieve good results in periodontally diseased molars, >50% bone support of the remaining roots at the time of the root resection is an important factor. Periodontal problems around resected molars have a tendency to recur and should be maintained through meticulous supportive periodontal treatment. In addition, a careful prosthetic plan should be designed to avoid a fracture of resected molars related to biomechanic impairment. Further prospective studies are needed to support these results.

ACKNOWLEDGMENTS

The authors acknowledge Dr. Seon-Woo Kim, Biostatics unit, Samsung Biomedical Research Institute, for her help in data analysis. The authors report no conflicts of interest related to this study.

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Submitted June 10, 2008; accepted for publication September 8, 2008.