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Original Research Article

A retrospective survey of autotransplantation of teeth in dental clinics

Running title: Autotransplantation of teeth in dental clinics

Key words: Autotransplantation of teeth, Survival rate, Survival time, Dental clinics,

Complete root formation

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Summary

The aim of this study was to investigate the usage of tooth autotransplantation in dental clinics which offer the treatment and evaluate its practicality. Participating dentists were requested to provide information on transplantations they had undertaken from 1 January 1990 to 31 December 2010. A total of 614 teeth from 552 patients (37 dentists) ranging in age from 17 to 79 (mean age: 44.1) were examined. Cumulative survival rate and mean survival time were calculated using the Kaplan-Meier method, and log rank test was used for analysis of factors. The mean number of autotransplantation patients per clinic per year was 1.4. Upper third molars constituted 36.8% of donor teeth, while 37.1% were lower third molars. The lower first molar region was the most common recipient site at 32.6%, followed by the lower second molar region (28.0%). Prosthodontic treatment of transplanted teeth involved coverage with a single crown (72.5%) and abutment of bridge (18.9%). A total of 102 transplanted teeth were lost due to complications such as attachment loss (54.9%) and root resorption (25.7%). The cumulative survival rate in cases where donor teeth had complete root formation was 90.1% at 5 years, 70.5% at 10 years and 55.6% at 15 years. The mean survival time was 165.6 months. Older age was a significant risk factor ($p < 0.05$) for survival. In cases where suitable donor teeth are available, autotransplantation of teeth may be a plausible treatment option for dealing with missing teeth in dental clinics.

Introduction

Reports of autotransplantation of teeth have been increasing since around 1950. Apfel (1) and Miller (2) described the transplantation of immature third molars to the first molar position in 1950. Since then, autotransplantation of immature teeth has often been performed in combination with orthodontic treatment to deal with problems such as impaction, aplasia and displacement (3-7). Andreasen et al. (3) reported on 370 autotransplanted premolars. They reported a 95% survival rate with observation periods ranging from 1 to 13 years.

Recently several reports have described autotransplantation of donor teeth with complete root formation with long-term observation (7-9). Mejare et al. (8) used third molars with complete root formation to replace a lost first or second molar, and the cumulative survival rate during a four-year follow-up period was 81.4%. Watanabe et al. (7) examined orthodontic patients and recorded a survival rate of 86.8% after a mean observation time of 9.2 years. Sugai et al. (9) observed 117 teeth and reported a five-year survival rate of 84%.

Tsukiboshi (10) and Akiyama et al. (11) described various cases of autotransplantation involving not only single crown but also abutment of bridge. However, most of these reports contained no discussion of the prosthodontic treatment of transplanted teeth, and the procedures were performed in the surgery departments at universities or hospitals. The use of tooth autotransplantation in private clinics and accompanying survival rates, on the other hand, has been largely undocumented. Therefore, a field survey to assess the situation in private dental clinics was warranted. The aim of this study was to investigate the usage of tooth autotransplantation in dental clinics which offer the treatment and evaluate its practicality.

Materials and Methods

Questionnaires were sent to 42 dentists who were members of a clinical research organization called “Kyushikai”, and who had engaged in tooth autotransplantation. These dentists were requested to provide information about all autotransplantations they had performed since opening their clinic. The observation period was from 1 January 1990 to 31 December 2010. A total of 39 dentists responded, providing data on a total of 637 patients and 708 transplanted teeth. Data from two of the dentists (38 patients, 42 teeth) was excluded because the respondents did not include data from all transplantations conducted at their clinics. Data concerning all teeth transplanted during 2010 (47 patients, 52 teeth) were also excluded, as it would not be possible to ascertain what kind of prothodontic treatment was used in these cases. After excluding this data, 614 teeth of 552 patients (mean age of 44.1 years) were examined in this study. Clinics were located in the Tohoku region (two clinics), the Kanto region (30 clinics) and the Tokai region (4 clinics) of Japan. The mean period of time the dentists had been practising since graduation from dental school was 23.2 years (ranging from 11 to 44) as of April 2010. Data collected included information about the patients, condition of donor teeth and recipient sites, date of last examination, prosthodontic treatment of and condition of transplanted teeth, and primary reason for tooth loss (when applicable).

The distribution of patients by age group is shown in Table 1. Patients consisted of 273 males (mean age of 44.6 years) and 279 females (mean age of 43.7 years), ranging from 17 to 79 years of age. Cases where two or more teeth were transplanted in the same patient within one year were counted as one

patient. However, when there was more than a one-year interval between transplantations in the same patient, each case was counted as a separate patient. In cases where a donor tooth was separated into two or three parts, each part was counted as one donor tooth and one recipient site.

Prosthetic treatment of transplanted teeth was categorised as follows: single crown (including resin filling and connecting crowns), abutment of bridge, abutment of overdenture, and others.

The observation period was from 1 January 1990 to 31 December 2010. Transplanted teeth which were still present at a patient's last visit to a clinic were considered to be surviving and therefore treated as censored cases under the Kaplan-Meier method. Tooth survival time was defined as the number of months from transplantation until the time of the last visit to a clinic at which it was considered to be surviving. Tooth survival time of a non-surviving tooth was defined as the number of months from transplantation until the time at which the tooth was extracted or recorded as lost at the clinic. Observation period by year of operation is shown in Table 2.

All unsuccessful transplants were included in the analysis, irrespective of the cause of failure. Failure was defined as loss of the transplanted tooth, and the main causes of failure were categorised as follows: root resorption, attachment loss, root fracture, caries, and others (including failure of initial healing). Transplanted teeth judged as surviving fell into the following categories: clinical success, root resorption, ankylosis, and others. Criteria for clinical success were the absence of root resorption, normal periodontal tissue, no excessive tooth mobility, and no deep pockets.

Many of the participating dentists based their treatment procedures on Andreasen et al. (3) and Tsukiboshi (10, 12). Surgical procedure did, however,

vary slightly among the dentists, so the details of the procedures used by the 37 dentists have been provided in Table 3. Treatment generally began with pre-operative oral cleaning, scaling, and polishing. The donor tooth was cleaned more carefully. Many dentists noted that they apply force to the donor tooth in the pre-operative stage in order to make the extraction easier. During the operation itself, the donor tooth was removed carefully to prevent damage to the periodontal ligaments. A socket was made in the recipient site using a carbide bur or diamond bur. After the opened flap was sutured, the transplanted tooth was splinted using sutures or wire or a combination of the two. Occlusal clearance was checked to ensure that the transplanted tooth did not make contact with opposing teeth. In post-operative treatment, the sutures were removed after one week and the splint was removed after around three weeks. Endodontic treatment was begun after two weeks. Calcium hydroxide, Vitapex® etc. were used as root canal disinfectant. All dentists used gutta-percha points for root canal filling. After prosthodontic treatment, regular maintenance was performed at intervals of 1 to 6 months.

Statistical Analysis

In calculating the cumulative survival rate of transplanted teeth, 15 cases in which the donor teeth had incomplete root formation were excluded. Only the data of the 599 cases in which the donor teeth had complete root formation were used. The cumulative survival rate and mean survival time were calculated using the Kaplan-Meier method. In the factor analysis, patients were divided into two age groups, those under 40 and those 40 and over. The statistical significance of the difference between the survival curves of the two groups was calculated by log rank test. The level of significance was set at 0.05. The data was analyzed

using the computerized statistical package SPSS, version 15.0 (SPSS, Inc.).

This study was approved by the ethical committee of Tokyo Dental College (Approval Number 269).

Results

The mean number of patients who underwent the procedure was 1.4 (± 1.2) per clinic per year. The mean observation period of transplanted teeth was 63.8 months (ranging from 0 to 237).

The number of transplanted teeth, distributed by donor tooth and recipient site, is shown in Table 2. Upper third molars constituted 36.8% of donor teeth, while 37.1% were lower third molars, 6.7% were premolars, and 5.0% were incisors. The lower first molar region was the most common recipient site at 32.6%, followed by the lower second molar region (28.0%), upper first molar region (13.2%), and upper second molar region (10.9%).

Prosthetic treatment of transplanted teeth consisted of a single crown in 72.5% of cases, abutment of bridge in 18.9% of cases, abutment of overdenture in 7.7% of cases, and other treatments in 1.0% of cases (Table 3).

A total of 102 transplanted teeth were lost during the post-operative observation period (Table 4). The main reasons for tooth loss were attachment loss (54.9%), root resorption (26.5%), caries (4.0%), root fracture (2.9%), and others (11.8%).

Among surviving teeth (512 teeth), 79.1% were deemed clinically successful, while 10.9% had root resorption, 4.7% had ankylosis, and 5.3% had other problems.

The cumulative survival rate in cases where donor teeth had complete root formation was 90.1% at the 5-year mark, 70.5% at 10 years, and 55.6% at 15 years (Figure 1). The mean survival time was 165.6 months, as calculated by the Kaplan-Meier method.

There was a significant difference ($p < 0.05$) in survival rate between younger patients (under 40) and older patients (40 and over) (Figure 2).

Discussion

Dentists participating in this study did not use a uniform, standardised surgical procedure. Of course autotransplantation of teeth requires highly-skilled techniques, and Andreasen et al. (3) and Tsukiboshi (12) have presented detailed surgical procedures. Kvint et al. (6) reported that surgical complications such as extraction difficulty, deviant root anatomy, and damaged root periodontium affect the success of the procedure. Future studies focusing on surgical technique are needed, but the purpose of this study was to investigate the usage of tooth autotransplantation in dental clinics.

The mean age of patients examined in this study (44.1 years) was higher than in previous studies (1-9), and age influenced the survival rate significantly. Sugai et al. (9) indicated that younger patients, under 40 years of age, showed a significantly better prognosis than older patients. Tsukiboshi (12) also noted a success rate of nearly 90% in patients under 40 years old. Kvint et al. (6) reported that the success rate of patients over 20 years of age was lower than that of younger patients. Schwartz et al. (13) also suggested that the age of the patient at the time of surgery has an effect on inflammatory resorption.

Previous studies have reported on the survival rate of transplanted teeth in cases of complete root formation. Watanabe et al. (7) reported on 38 autotransplantations in 32 patients, where the mean age at the time of surgery was 24.1 years. More than six years after autotransplantation, 33 teeth had survived in 27 patients. The survival rate was 86.8% with a mean observation time of 9.2 years. Sugai et al. (9) conducted 117 complete root formation transplants on 109 patients ranging from 11 to 75 years of age (mean age of 39.0). Of the 117 transplants investigated, 14 (12%) failed during the observation period. The overall five-year survival rate was 84%. Mejare et al. (8) studied 50 patients ranging from 21 to 66 years of age (mean age of 36.7 years) in which a total of 50 third molars with completely developed roots were autotransplanted to replace a lost first or second molar in the same number of admitted patients. The cumulative survival rate during a four-year follow-up period was 81.4%.

In this present study the survival rate was 90.1% at five years and 70.5% at ten years. Considering the higher-than-average age of the patients, these results are reasonably in line with the results of previous studies.

Concerning the causes of loss of transplanted teeth, Watanabe et al. (7) looked at five lost teeth and found that in one case periodontal disease was the cause, one case was due to inflammatory resorption, and the remaining three cases were caused by replacement resorption. Sugai et al. (9) reported that of the 117 transplants investigated, 14 (12%) failed during the observation period. Failure of the initial healing was to blame in five of these instances, and a combination of replacement root resorption and periodontal inflammation was to blame in another five of the cases. Mejare et al. (8) reported that out of 50 third molars with completely developed roots which were autotransplanted to replace a lost first or second molar, seven transplants were lost during the follow-up

period. Four of these were due to marginal periodontal pathosis, while the other three were due to root resorption.

The main causes of loss of transplanted teeth in this present study were attachment loss (54.9%) and resorption (26.5%). Additionally, even among transplanted teeth judged as surviving, 20.9% had problems such as root resorption and ankylosis. Although the dentists in this study did not use a standardised procedure for maintenance, these results were in line with previous reports.

In the case of one or two lost teeth in adults, dentists usually choose from the treatment options of autotransplantation, bridge, or implant. Tan et al. (14) reported the ten-year probability of survival for fixed partial dentures to be 89.1%. Results of a meta-analysis of resin-bonded bridges indicate an estimated five-year survival of 87.7% (15). In a review of single crown restorations on implants, five-year survival was 96.8% (16). Lekholm et al. (17) reported on the Brånemark Implant System, which has a survival rate of 90.2% at ten years.

In Japan, Aoyama et al. (18) calculated the survival rate and survival time for metal bridges in a dental clinic, using the Kaplan-Meier method. The survival rate was 55.6% at five years and 31.9% at ten years. The mean survival time was 85.2 months. Suito et al. (19) reported on immediate implant restoration, for which the survival rate at nine years was calculated to be 94.7% using the Kaplan-Meier method.

In this study, the cumulative survival rate for autotransplantation was 70.5% at ten years, and the mean survival time was 165.6 months. In view of survival rates, implants are generally preferable to other treatment options. However, when successful, transplanted teeth have some strong merits that should not be overlooked. For example, the periodontal ligaments remain, allowing for the

movement of teeth (3-7) and promoting bone regeneration (11). Autotransplantation also eliminates the need to prepare teeth for bridges. Additionally, in Japan autotransplantation can be provided at a lower cost than implants, as national health insurance covers the autotransplantation of third molars if the donor tooth is placed immediately after extraction. Taking these benefits into account, along with the results of this and previous studies, autotransplantation is a valid treatment option that dentists should explore before automatically choosing to use a bridge or implant. If suitable donor teeth are available, autotransplantation of teeth may be a plausible treatment option for dealing with missing teeth in dental clinics.

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Table 1. Number of patients by age group

Age group	Males	Females	Total	%
10-19	2	2	4	(0.7)
20-29	40	52	92	(16.7)
30-39	71	62	133	(24.1)
40-49	57	68	125	(22.6)
50-59	53	48	101	(18.3)
60-69	45	35	80	(14.5)
70-79	5	12	17	(3.1)
Total	273	279	552	(100)

Table 2. Observation period by year of operation (number of teeth)

Year of operation	Observation period* (years)				total	%
	0-4	5-9	10-14	15-20		
1990-94	12	12	7	18	49	(8.0)
1995-99	39	48	54	6	147	(23.9)
2000-04	62	100	13		175	(28.5)
2005-09	232	11			243	(39.6)
Total					614	100

*Observation period is the period from operation to last dental clinic visit or loss of transplanted teeth

Table 3. Procedure of tooth transplantation employed by participating dentists (n = 37)

		Treatments	Number of dentists (%)	
Pre-operation	Donor tooth	Scaling and polishing	37 (100)	
		Application of force	29 (78.4)	
		Instrument:		
		Orthodontic device	15 (51.7)	
		Only elastic	14 (48.3)	
		Luxation several days before extraction	3 (8.1)	
		Endodontic treatment	4 (10.8)	
	Recipient site	Advance extraction (Always)	5 (17.2)	
		Same-day extraction (If possible)	32 (86.5)	
Operation	Recipient site	Suture material:	Silk	23 (62.2)
			Nylon	14 (37.8)
		Splinting method:	Suture + wire	27 (73.0)
			Only suture	8 (21.6)
			Others	2 (5.4)
Post-operation	Transplanted teeth	Splint removal:	2 weeks*	9 (24.3)
			3 weeks*	10 (27.0)
			4 weeks and more*	17 (45.9)
		Endodontic treatment: (n=33)	2 weeks*	9 (24.3)
			3 weeks*	12 (32.4)
			4 weeks or more*	12 (32.4)
		Disinfectant:	Calcium hydroxide	25 (67.6)
			Vitapex®**	4 (10.8)
			Others	8 (21.6)
		Filling material:	Gutta-percha points	37 (100)
Prosthodontics	Transplanted teeth	Setting of prosthodontics:	1-3 months*	26 (70.3)
			4-6 months*	7 (18.9)
			9-12 months*	4 (10.8)
Maintenance		Check-up frequency:	Every 1-3 months	17 (45.9)
			Every 4-6 months	20 (54.1)

* Period of time from operation until initiation of treatment.

** Vitapex® includes calcium hydroxide, iodoform, and others.

Table 4. Number of transplanted teeth, distributed by donor teeth and recipient site

			Recipient site												Total	%						
			Upper						Lower													
			Incisors			Premolars			Molars			Incisors					Premolars			Molars		
			First	Second	Third	First	Second	Third	First	Second	Third	First	Second	Third			First	Second	Third	First	Second	Third
Donor site	Upper donor teeth	Incisors	First	2								1	1						4	(0.7)		
			Second	2				2									6			10	(1.6)	
			Third		1		1						1	2			1	1		7	(1.1)	
		Premolars	First					1										3			4	(0.7)
			Second	1	1	1	1	2							3			7	1		17	(2.8)
			Third																			
	Molars	First		1		1	3							3	2	3				13	(2.1)	
		Second			1	2	2	7						7	21	4				44	(7.2)	
		Third	1			3	7	33	44					1	5	67	65			226	(36.8)	
	Lower donor teeth	Incisors	First		1		1								2	2				6	(1.0)	
Second				1					1										2	(0.3)		
Third									1						1				2	(0.3)		
Premolars		First			1		1	2							1	4				9	(1.5)	
		Second		1		1	2		1					1	2	2	1			11	(1.8)	
Molars		First				1	1								1	2				5	(0.8)	
		Second				1	3	9	2					1	3	4	3			26	(4.2)	
		Third	1			3	1	28	20					1	1	79	94			228	(37.1)	
		Total	7	6	3	15	25	81	67				2	7	29	200	172			614		
	%	(1.1)	(1.0)	(0.5)	(2.4)	(4.1)	(13.2)	(10.9)	(0)	(0)	(0.3)	(1.1)	(4.7)	(32.6)	(28.0)							

*If a donor tooth was divided into two or three parts, each part was counted as one donor tooth and one recipient site.

Table 5. Prosthodontic treatment of transplanted teeth

	Number of teeth	%
Single crown*	445	(72.5)
Abutment of bridge	116	(18.9)
Abutment of overdenture	47	(7.7)
Others	6	(1.0)
Total	614	100

* Single crown includes resin filling and connecting crowns.

Table 6. Main causes of transplantation failure (n=102)

Main causes	n	%
Attachment loss	56	(54.9)
Root resorption	27	(26.5)
Caries	4	(4.0)
Root fracture	3	(2.9)
Others	12	(11.8)
Total	102	100

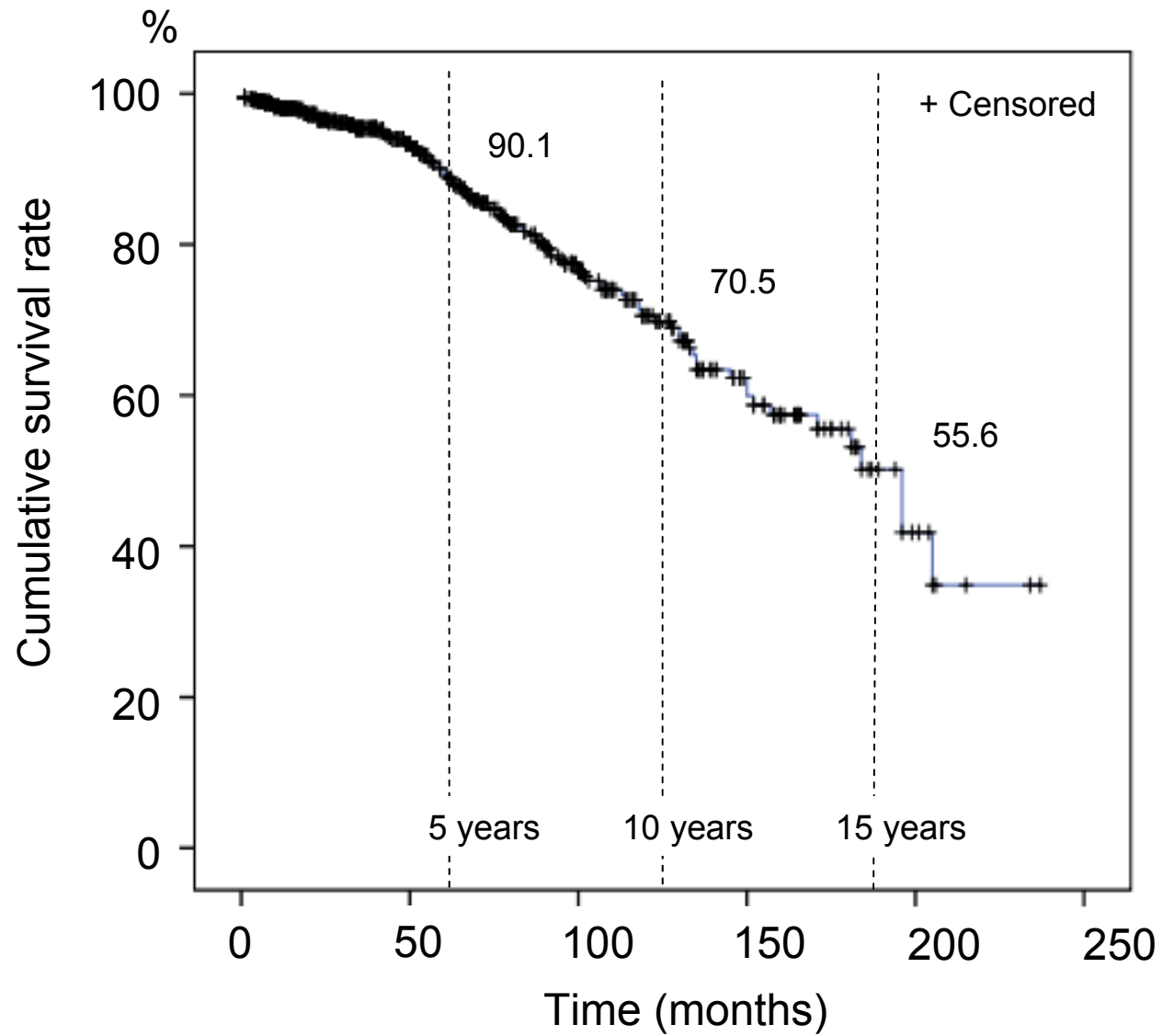


Figure 1. Survival analysis of autotransplanted teeth by Kaplan-Meier method (n=599)

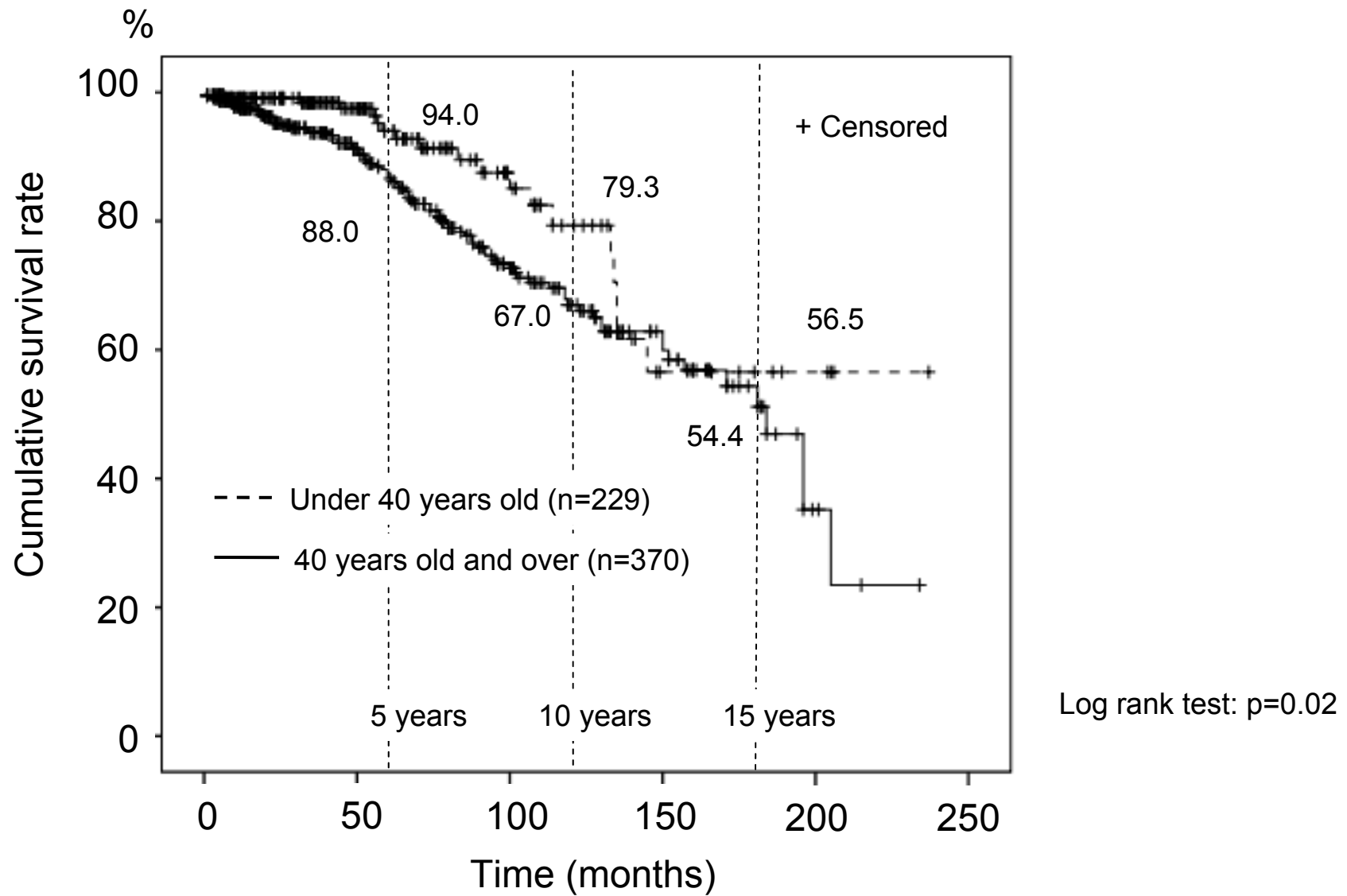


Figure 2. Survival analysis of autotransplanted teeth by age group