Factors Affecting Survival of Primary Teeth

Receiving Interim Therapeutic Restorations in a Pediatric Population

Ya-Chun Wang

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Committee:

Ana Lucia Seminario

Penelope Leggott

JoAnna Scott

John Wataha

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University of Washington

Abstract

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Chair of the supervisory committee:

Professor Ana Lucia Seminario

Department of Pediatric Dentistry

Purpose: To determine the overall survival rate of primary teeth treated with interim therapeutic restoration (ITR) in pediatric patients, to identify the variables that are associated with the success rate of interim therapeutic restoration, and to compare the survival rate for variables of interest.

Methods: Charts from approximately 5000 inactivated patients in a rural Washington state private general dental office were reviewed. Inclusion criteria included children older than two years with initial ITR on a primary tooth that was asymptomatic and had no previous restoration. Two hundred and five charts were selected. Data collected included patient demographics, the initial date of ITR placement, and the baseline dmft/DMFT (decayed, missing, or filled teeth). When available, prospective data collected included follow-up appointment dates, dmft/DMFT, and any relevant treatment outcomes of restorative treatment, pulp treatment, and extraction. Data was captured using REDCap Software Version 5.7.3 (Vanderbilt University) and then imported into Stata 12.0 (College Station, TX) for analysis. Descriptive statistics was calculated

for all variables. Kaplan-Meier survival curves were calculated for overall treatment success. Log-rank statistics were used to compare survival rates for variables of interest.

Results: The overall median survival time of teeth receiving ITR restorations was 8.3 years. Age, gender, baseline DMFT/dmft, tooth type, and number of ITR surfaces are not associated with tooth survival time. The only variable found to have a significant association with tooth survival was health status of the child.

Conclusions:

- A long median survival time of primary teeth treated with ITR was observed in this study.
- Healthy children had significantly longer survival rates for primary teeth treated with ITR than those who were not healthy.
- Replenishing ITR is an effective method to treat primary teeth with caries until their natural exfoliation or until a permanent restoration can be placed.

ACKNOWLEDGEMENTS

I would like to thank my research committee for their guidance and support. In particular, I would like to thank Dr. Scott for her expertise in biostatistics to make this project possible. I would also like to thank Dr. Seminario and Dr. Leggott for their mentorship. And lastly, I would like to thank Dr. Wataha who has been an influential faculty mentor to me since my pre-doctoral dental education.

DEDICATION

I dedicate this thesis to my husband, Kevin, my mother Sandy, my father Kelly, and my two children Iris and Levi for their love, understanding, and support. I truly appreciate all the sacrifice they have made throughout this residency.

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INTRODUCTION

History

In the 1980s, a pilot study conducted in Tanzania indicated a reduction in the need for extraction after removal of soft demineralized dentin from dental cavities that were then filled with polycarboxylate cement. Only one of twenty-eight teeth treated in this manner was extracted, while the remainder were asymptomatic nine months after treatment.[1] Since the initial study, this technique evolved and was refined to utilize a hand instrument such as a hatchet or an enamel access cutter to enlarge the orifice of small cavities, which were then restored with glass ionomer material. This technique was known as the atraumatic restorative treatment (ART) approach in the 1990s.[1] In a special issue published in the *Journal of Public Health Dentistry,* Frencken *et al.* suggested that a major obstacle to delivery of restorative dental care in developing countries was the lack of electric driven dental equipment needed for traditional dental treatment.[2] ART offers a method to manage and prevent caries progression in these environments and has been endorsed by the World Health Organization.[2]

Technique & Materials

ART is defined as a minimal intervention approach to manage caries and to stop the progression of carious lesions when definitive materials are not able to be placed either because of the logistical situation or because of the behavior of the patient.[3,4] The two components of ART are to 1) seal caries-prone pits and fissures and 2) to restore dentin carious lesions.[3] Hand instruments are used to excavate soft and completely demineralized dentin after creation of sufficient access to the caries lesion. The lesion is then restored using an adhesive material that fills the cavity and seals remaining fissures and pits.[1] In the earlier years of ART, medium viscosity glass-ionomer (GI) was the material of choice, but suffered from high rates of wear.

Since the 1990s, high viscosity glass-ionomer has become the preferred material for ART restoration.[3]

Indications

The ART technique allows for removal of caries without rotary instruments, local anesthetic, or the need for rubber dam placement, all of which can be advantageous when treating pediatric and special needs populations. When compared with conventional dental treatment, ART causes less discomfort and pain in children.[5,6] Dental anxiety also is lower both in children and adults treated by ART compared to traditional restorative treatment.[7] According to a meta-analysis, in primary teeth, single-surface and multiple-surface ART restorations have survival rates of 93% and 62% respectively over the first 2 years.[8] Mean and median estimated times of survival of ART restorations in single-surface primary teeth were 37 months and 38 months respectively, while the survival rates were 94% and 20% at 12 and 48 months, respectively.[9] Based on these findings, ART has been advocated as a treatment option for young patients, patients with special needs, and uncooperative patients.[10]

Interim Therapeutic Restorations

Interim therapeutic restorations (ITR) differ from ART restorations in the method of cavity preparation. Because ITR involves the removal of caries using slow speed rotary instruments, it is a more suitable term to describe the ART- procedure used in contemporary dental practices in the US. In addition, the goal of ITR is to restore and prevent further demineralization and dental caries when traditional restorations are unable to be placed.[10]

Comparison between conventional restorations and ART

Concerns have been raised about residual infected demineralized dentin that is not removed in an ART procedure, and the longevity of ART compared to the other treatment options. Mandari *et*

al. (2001) have reported that survival of occlusal ART restorations after 2 years was not significantly different compared to a conventional approach.[11] Single surface ART using glass-ionomer has a significantly higher survival rate when compared with teeth treated with a traditional approach such as amalgam. Similarly, multi-surface restorations survive as well after 3 years as teeth restored traditionally.[12] A systematic review reported that there were no significant differences between the longevity of restorations placed in primary teeth by ART approach versus conventional amalgam restorations up to 2-years after initial placement.[13] Collectively, these studies suggest that ART is a promising interim restorative strategy.

Factors associated with ART survival rate

Several factors affecting the success of ART restorations have been identified. Multi-surface ART restorations have a lower survival rate compared to single-surface restorations.[5,8,11,14] Other factors such as marginal gap, partial material loss, complete material loss, caries related to restoration margins, and material wear greater than 0.5 mm were also identified as contributors to restoration failure.[15,16] However, when comparing the factors of gender, age of patient (12-36 months vs. 37-48 months), arch (upper vs. lower), and segment (anterior vs. posterior), there were no significant differences in the survival rate of ART restorations .[9]

General dentists' attitude toward ART

A cross-sectional survey of general dental practitioners conducted in Hong Kong reported that ART was the preferred treatment option for a hypothetical 4-year-old healthy and cooperative boy, whereas pediatric dentists favored conventional restorative treatment for the same patient.[17] A second cross-sectional survey conducted in England reported similar results where ART was the preferred method among the general dental practitioners to restore a primary molar with a proximal lesion in a six-year-old boy.[18] Since general dental practitioners have greater propensity

to use the ART technique, it is important to examine the outcome and survival of ART in these circumstances.

OBJECTIVES

ART is a technique endorsed by the WHO for regions of the world where the circumstance does not allow for conventional restorative treatment or follow up care. Compared to ART, ITR has different therapeutic goals and while the procedure is similar, it can involve the use of rotary instruments.[10] However, current literature on the survival time of *primary teeth* that received ITR rather than survival of the restoration itself is lacking. The aims of this retrospective longitudinal study were to 1) describe the overall survival rate of primary teeth receiving ITR and by selected variables of interest and 2) identify demographic and dental variables associated with the success rate of teeth restored by ITR.

METHODS

Study Population

Blaine Harbor Dental is a general dental practice that serves the greater Vancouver, B.C. and Bellingham, WA areas. This practice is maintained by a general dentist who provided dental care for children on Medicaid from 1998 to 2008, at time during which he placed many ITRs in children who could not tolerate the procedures involved for permanent restorations.

Technique

The general dentist followed the *Atlas of Pediatric Dentistry* guidelines on ITR placement written by University of Washington pediatric dentistry faculty members Devereaux Peterson and John Davis.[19] This technique was included in the Access to Baby & Child Dentistry (ABCD) training manual.[20] The ABCD program was first implemented in Spokane County in Washington State in 1995 to improve access to oral care for the state's most vulnerable pre-school children. The success of this program has led to its adoption in many other counties across Washington State. For ITR restorations performed in this study, caries was removed using the most efficient method tolerated by the child, which included a combination of hand instruments, slow speed rotary instruments, or high speed rotary instruments. Cotton rolls were used for isolation. Neither matrices nor wedges were placed. Vitrebond™ light-cure glass ionomer liquid and powder (3M ESPE) was hand-mixed, applied to the cavity preparation, and halogen light-cured for 20 seconds, according to the manufacturers' instructions.

Data Collection

Paper charts of approximately 5,000 inactivated patients were reviewed from the aforementioned general dental practice. This chart review was approved by the University of Washington Institutional Review Board. Inclusion criteria included children with at least one initial ITR

placement on a primary tooth that was asymptomatic and had no previous restoration. Only one instance of ITR placement was used for each child. Initial ITR placement was defined as the first instance of ITR recorded in the patient chart. Bitewings or periapical radiographs taken at the recall appointments were only utilized to estimate the date of natural exfoliation of the primary tooth of interest when it was not available in the odontogram.

Two hundred and five patient charts were included in the study. Twenty-seven patients were excluded from the analysis as they did not attend the first follow-up appointment after the initial placement of the ITR restoration. The remaining 178 patients included in the final analysis returned for at least one follow up appointment as a part of preventative recall appointments recommended by the dentist.

Demographic Variables

The following demographic variables were extracted from the patient charts: child's date of birth, gender; and health status. Age was calculated as date of initial ITR placement minus the child's date of birth and then categorized based on dental development as follows: 1) 0-2 years (prior to full set of primary dentition), 2) 3-6 years (full primary dentition), and 3) 7-12 years (mixed dentition, prior to full permanent dentition). Health status was categorized as healthy versus not healthy, based on the abbreviated medical history form. The not healthy category included children with asthma or other conditions.

Dental Variables

The following dental variables were extracted from the patient charts: number of decayed, missing, or filled teeth (DMFT or dmft) at initial ITR placement (DMFT for permanent teeth and dmft for primary teeth; if both permanent teeth and primary teeth were present, DMFT and dmft were combined); location of the ITR placement (anterior versus posterior); number of tooth

surfaces restored with ITR. DMFT and dmft were categorized into 3 groups: 1) 1-2, 2) 3-4, and 3) 5 or more. The number of surfaces restored with ITR was categorized as 1) 1 surface, 2) 2 surfaces, and 3) 3 or more surfaces. (Figure 1).

Definition for ITR Treatment Outcome

The type and date of ITR treatment outcomes were recorded at each recall appointment. The tooth of interest was followed based on dentist's discretion and patient's adherence. Outcomes were categorized as follows:

1. *Extraction.* The dental record indicated that the ITR tooth was extracted, due to either abscess or clinical symptoms of necrotic pulp or irreversible pulpitis. Date of the extraction was recorded as indicated in the patient chart.
2. *ITR remains without treatment*. Tooth receiving ITR restoration had no symptoms, had no redo recorded, or had a dental note indicating that ITR was "holding up well". No date is associated with this outcome.
3. *Natural exfoliation*. The tooth was considered to be naturally exfoliated when this event was indicated in the dental history or odontogram. When these records were not available, either bitewing or periapical radiographs were reviewed. The date of exfoliation was then approximated based on whichever event occurred first: 1) there was radiographic evidence of significant primary tooth root resorption, while the permanent successor tooth bud had erupted at or above the alveolar bone level, or 2) recall radiograph revealed loss of primary tooth, or 3) recall radiograph indicated eruption of its permanent successor.

4. *ITR replaced by composite at a later date*. Record indicated that composite was placed by the pediatric dentist. Note: A pediatric dentist was only available from February 2008 to December 2008. Date of the composite was recorded as indicated in the patient chart.
5. *ITR replaced by stainless steel crown (SSC)*. Dental record indicated that SSC was placed by the pediatric dentist. Date of the SSC was recorded as indicated in the patient chart.
6. *Pulpotomy and SSC*. The dental record indicated that pediatric dentist determined such treatment was needed. Date of the pulpotomy and SSC was recorded as indicated in the patient chart.
7. *ITR redo*. The dental record indicated ITR redo. Date of the ITR redo was recorded as indicated in the patient chart.
8. *Abscess*. The dental record indicated that there was an abscess. Date of the abscess was recorded as indicated in the patient chart. Subsequent treatment varied, and is not included in the data analysis.
9. *Pain.* A tooth received pain as an outcome if its condition fit the description of irreversible pulpitis or if abscess, extraction, or antibiotic treatment occurred. Date of pain was recorded as indicated in the patient chart.

For purposes of data analysis of treatment outcome, the first failure event documented in the dental chart (extraction, abscess, and pain) was then recorded.

Definition of ITR Treatment Failure

Prevention of caries progression into the pulpal tissue of the tooth is the primary therapeutic goal of ITR. Extraction, pulpotomy, abscess, and pain were designated as failures because these treatments were performed in response to caries progression into the pulpal tissue of the tooth, which does not meet the primary therapeutic goal of ITR. Natural exfoliation, ITR replaced by

composite or SSC at a later date, and ITR redo were not considered as failures because these are compatible with caries not progressing into the pulpal tissue of the tooth.

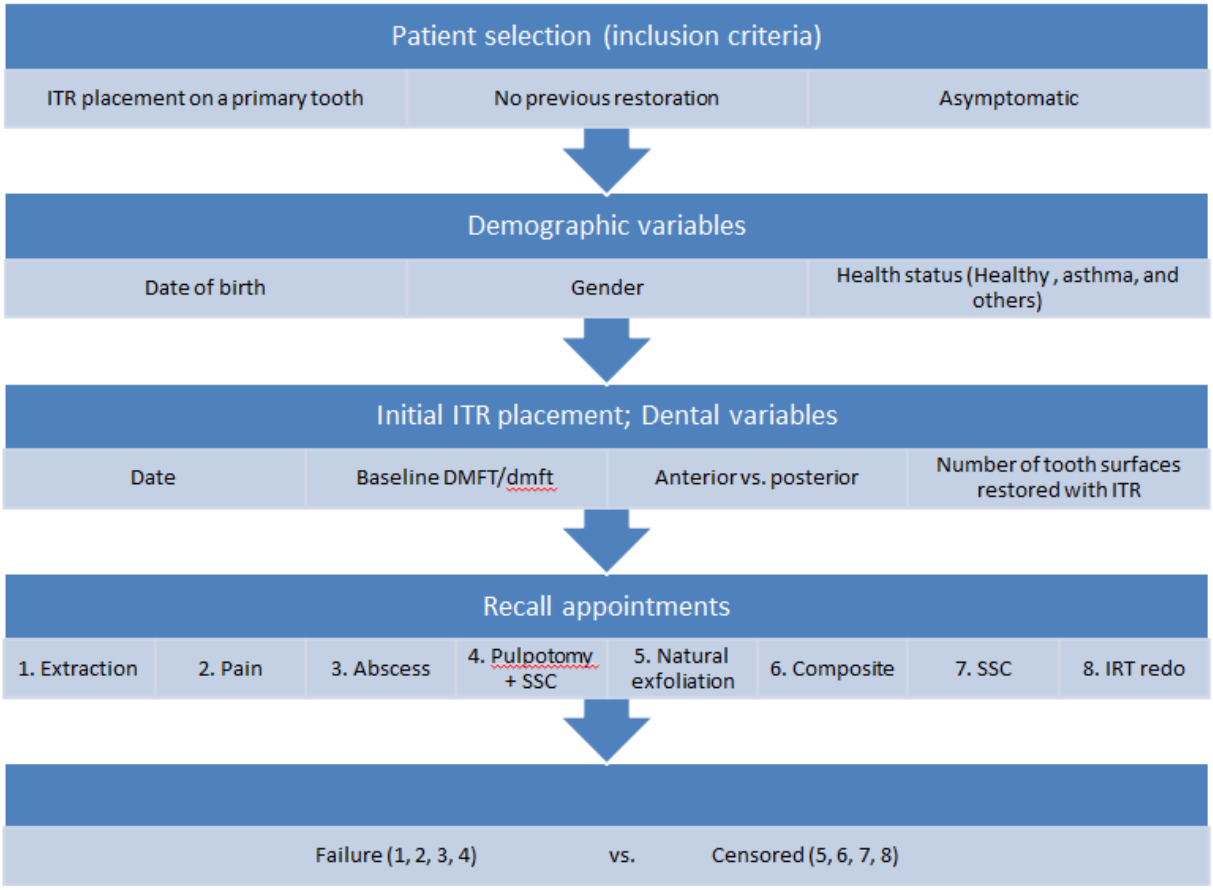

Figure 1. Flow diagram for data collection process.

Data Analysis

Data were captured using REDCap Software Version 5.7.3 (Vanderbilt University) and then imported into Stata 12.0 (College Station, TX) for analysis. Descriptive statistics were calculated for all variables. Kaplan-Meier survival curves were calculated for overall treatment success and to demonstrate survival rate versus each variable. Log-rank statistics were used to compare survival rates for variables of interest.

RESULTS

Descriptive Statistics

Of the initial 205 patients, 27 patients were excluded from the study because they did not return for follow up appointments after initial placement of the ITR restoration. A total of 178 patients were included in the analysis.

The first ITR was placed in February 2000, while the last ITR was placed in March 2009. Time between the initial ITR placement and the last visit ranged from 16 days to 8.34 years with an average time span of 2.6 years (standard deviation (SD)=1.7).

The number of recall appointments after the initial ITR placement ranged from one to 11 appointments with an average of 3.5 appointments (SD=2.5). Time from initial ITR placement to first recall ranged from 16 days to 4.4 years with an average of 0.8 years (SD=0.8).

Of the 178 patients included, 35 patients had teeth that failed to survive after receiving ITR (19.7%). Among the 35 failures, 14 (40.0%) were extracted, eight (22.9%) received pulpotomy with SSC, nine (25.7%) developed abscess, and four (11.4%) had pain.

There were 92 boys (51.7%) in the sample and the majority of patients was considered healthy (84.3%) and in the age range 3-6 years (63.5%). Most of the children (37.6%) had five or more decayed, missing, and filled teeth (DMFT/dmft). No child had a baseline DMFT/dmft score of zero. Teeth receiving ITR restorations were primarily posterior teeth and had 1-2 restored surfaces. (Table 1).

Survival Analysis

The overall median survival time of teeth receiving ITR restorations was 8.3 years (95% confidence interval (CI) = (5.19, infinity (inf)), which indicates that the probability of a tooth receiving ITR restoration that survives 8.3 years is 50%. (Figure 2).

Table 2 demonstrates the associations between the demographic and dental variables with survival time of primary teeth using ITR approach. Age, gender, baseline DMFT/dmft, tooth type, and number of ITR surfaces are not associated with tooth survival time. (Figures 4 - Figure 8). The only variable found to have a significant association with tooth survival was health status of the child. The survival probabilities for teeth receiving ITR in healthy children are higher than the survival probabilities in non-healthy children ($p=0.020$). (Figure 3).

DISCUSSION

The current study differs from other studies in that it examines the survival time of primary teeth that received ITR restorations rather than the survival of the restorations. This could account for the difference in survival times seen in previous studies. [9,21] The present study shows a substantial median survival time of 8.3 years with an overall treatment failure rate of 19.7%. However, the average length of time between the initial ITR placement and the last visit had an average time span of 2.6 years. The substantial median survival time is most likely due to a low overall ITR failure rate.

High viscosity glass ionomer cements have traditionally been the material of choice for ART restorations since the 1990s, due to their superior physical properties.[3,22] However, in this study, Vitrebond™, a low viscosity resin modified glass ionomer cement, was used for ITR. The satisfactory survival times (Table 2) may be attributed to the material's ability to adapt to the cavity preparation, release fluoride, adhere to the dentin and enamel, exhibit biocompatibility, and provide effective sealing of dentinal tubules. [23–26]

As in previously published studies, the current study found no significant difference in survival rates between different age groups, anterior vs. posterior teeth, or genders. [9] In addition, previous studies report that multi-surface ART restorations have lower survival rates. However, this study found no significant difference in survival rates of primary teeth receiving single versus multi-surface ITR restorations.[27–29] One explanation is that in the current study the tooth that received the ITR could have multiple replacements as needed, which was not considered to be a failure. In the course of replacing or repairing the ITR restorations, the tooth would have had chance to replenish the fluoride into the tooth structure and to repair the defected margins,

which are known to increase the success rate of ART restorations.[15] Therefore, single surface vs. multi-surface ITR restorations would not have different tooth survival times.

In the National Health and Nutrition Examination Survey (NHANES) from 1999-2004, children aged two to 11 had a caries prevalence of 42% and an average of decayed or filled primary teeth (dft) score of 1.6. [30] In this present study, children seen from 1998 to 2008, ranged from 10 months to 12 years old, and had an average dmft/DMFT of 4.5 (SD=2.7), which is nearly three times higher than the national average at that time. The present study suggests that baseline DMFT/dmft scores are not associated with tooth survival rates in children zero to 12 years old. This reflects that the survival time of teeth receiving ITR restorations is not affected by baseline caries experience. A study conducted among adolescents also concluded that DMFT have no effect on the cumulative survival percentages of all ART restorations over evaluation years one and five.[31] A plausible explanation is that in our study, the children had eventually reached similar caries experience as measured by DMFT/dmft as time progressed through the survival analysis curve.

There are several limitations in the current study. First, once a tooth has been recorded as being a treatment success (tooth naturally exfoliates, or receives a permanent restorations, including a composite or a SSC) it was considered to be censored. Therefore, it is no longer included in the survival analysis. However, such teeth remained at risk for failing and hence the Kaplan-Meier calculations may be biased. Second, no specific clinical criteria for reliability of treatable lesion characteristics were described before the initial ITR placement. Third, the dental charts were missing the description of the ITR restoration at each appointment regarding its marginal integrity and degree of wear and the reason for ITR replacement. So, it was unclear whether there was recurrent caries, advancement of caries, or new caries on different surfaces after the

initial ITR placement, or whether or not the replacement was due to wear or loss of retention. Furthermore, radiographs were not available to analyze the presence of dentin formation, nor were they used to assess bone level or pathology. Therefore, for this study, radiographs were only used to estimate the date of exfoliation when it was not clearly demonstrated in the odontogram. The time of ITR survival to its natural exfoliation was therefore only an estimate, not the true interval. All these factors likely influenced the theoretical longevity of the ITR. Interestingly, these limitations may also provide evidence of the success of this technique when used in a real world setting. Specifically, this study defined hard outcomes (tooth survival) that are of interest to general dentistry. This paper is the first study in a general dental practice setting for this technique and it has demonstrated a long median survival time of the tooth that was treated with ITR and found a significant difference in survival rates between healthy and non-healthy children. One plausible explanation might be for children with medical conditions, it may be difficult for the family to adhere to the recommended preventative regimes, including oral hygiene, dietary control, and regular dental appointments.

The substantial survival time of these primary teeth receiving ITR in a general dental practice should be highlighted. The American Academy of Pediatric Dentistry calls for children to establish a dental home by age one.[32] General practitioners and pediatric dentists together should assume the responsibility to deliver oral health care to children. The ITR technique provides general practitioners and pediatric dentists with a successful method for containing dental caries when restoring a tooth using conventional methods is not possible.

CONCLUSIONS

- A long median survival time of primary teeth treated with ITR was observed in this study.
- Healthy children had significantly longer survival rates for primary teeth treated with ITR than those who were not healthy.
- Replenishing ITR is an effective method to treat primary teeth with caries until their natural exfoliation or until a permanent restoration can be placed.

Table 1: Interim Therapeutic Restoration (ITR) Failure Rate Stratified By Patient Characteristics

		Failure Rate (n (%))		
		No	**Yes**	**Total**
Overall		143 (80.3%)	35 (19.7%)	178 (100.0%)
Age				
	0-2	15 (10.5%)	4 (11.4%)	19 (10.7%)
	3-6	91 (63.6%)	22 (62.9%)	113 (63.5%)
	7-12	37 (25.9%)	9 (25.7%)	46 (25.8%)
Gender				
	Male	71 (49.7%)	21 (61.11)	92 (51.69)
	Female	72 (50.3%)	13 (36.11)	85 (47.75)
	Missing	--	1 (2.9%)	1 (0.56%)
Healthy				
	No	18 (12.6%)	10 (28.6%)	28 (15.7%)
	Yes	125 (87.4%)	25 (71.4%)	150 (84.3%)
Baseline DMFT/dmft				
	1-2	33 (23.1%)	9 (25.7%)	42 (23.6%)
	3-4	42 (29.4%)	7 (20.0%)	49 (27.5%)
	5+	52 (36.4%)	15 (42.9%)	67 (37.6%)
	Missing	16 (11.2%)	4 (11.4%)	20 (11.2%)
Tooth location				
	Anterior	38 (26.6%)	4 (11.4%)	42 (23.6%)
	Posterior	105 (73.4%)	31 (88.6%)	136 (76.4%)
Number of ITR surfaces				
	1	57 (39.9%)	12 (34.3%)	69 (38.8%)
	2	68 (47.6%)	21 (60.0%)	89 (50.0%)
	3+	18 (12.5%)	2 (5.7%)	20 (11.2%)

Table 2: Interim Therapeutic Restoration (ITR) Survival Time And Association By Variables

	Median Survival Time (yr)	95% CI	p-value*
Overall	8.34	(5.19, inf**)	N/A
Child Age			0.505
0-2	inf	(2.34, inf)	
3-6	6.02	(5.19, inf)	
7-12	4.41	(3.49, inf)	
Gender			0.552
Male	8.34	(4.51, inf)	
Female	5.69	(5.19, inf)	
Healthy			0.020
No	4.41	(2.02, inf)	
Yes	8.34	(5.69, inf)	
Baseline DMFT/dmft			0.460
1-2	5.19	(4.51, inf)	
3-4	inf	(5.69, inf)	
5+	8.34	(6.02, inf)	
Tooth location			0.122
Anterior	inf	(inf , inf)	
Posterior	6.02	(4.51, inf)	
Number of ITR surfaces			0.150
1	8.34	(5.19, inf)	
2	6.02	(4.41, inf)	
3+	inf	(inf , inf)	

*Calculated using a Log-Rank Test.
**inf = Infinity

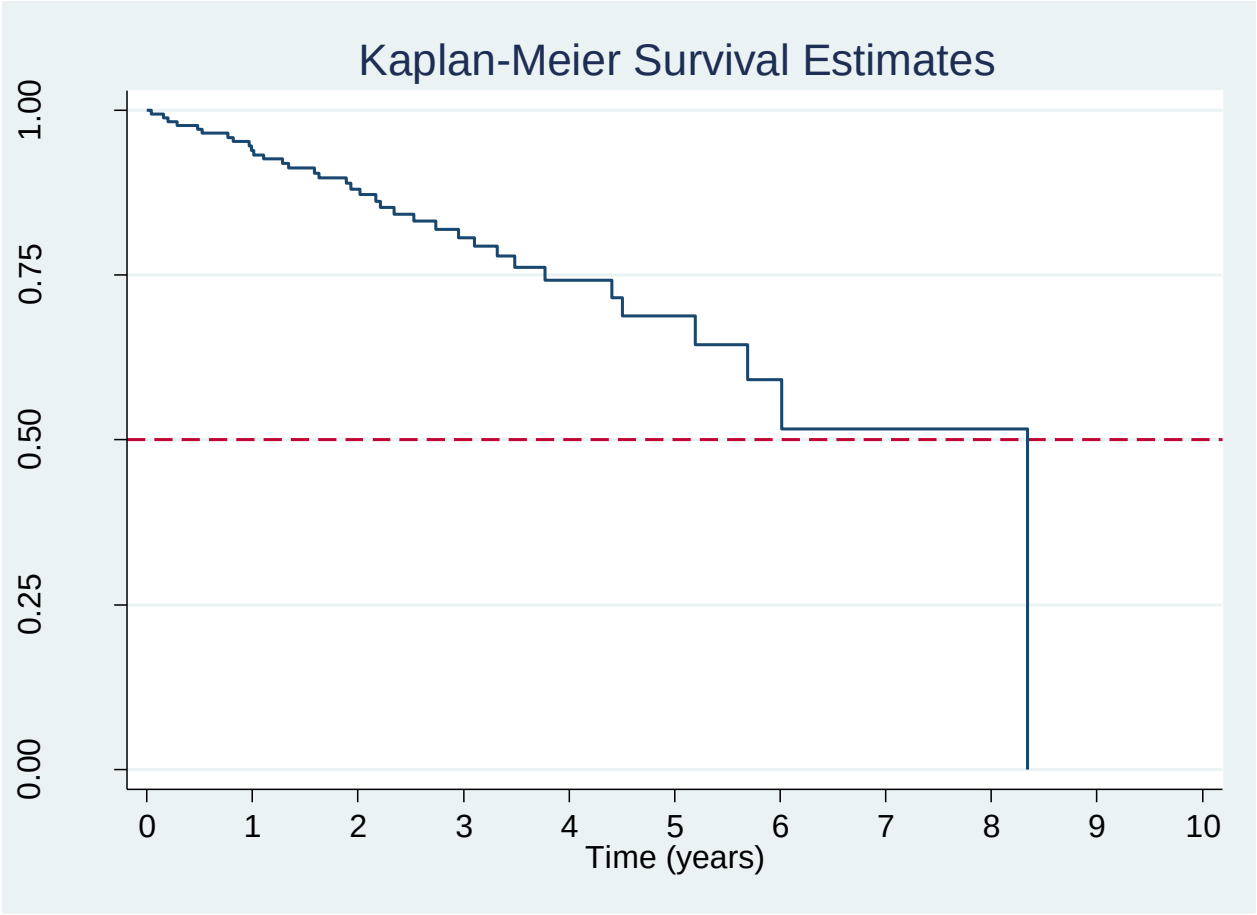

Figure 2. Overall Median Survival Time For Primary Teeth Receiving Interim Therapeutic Restorations (ITR)

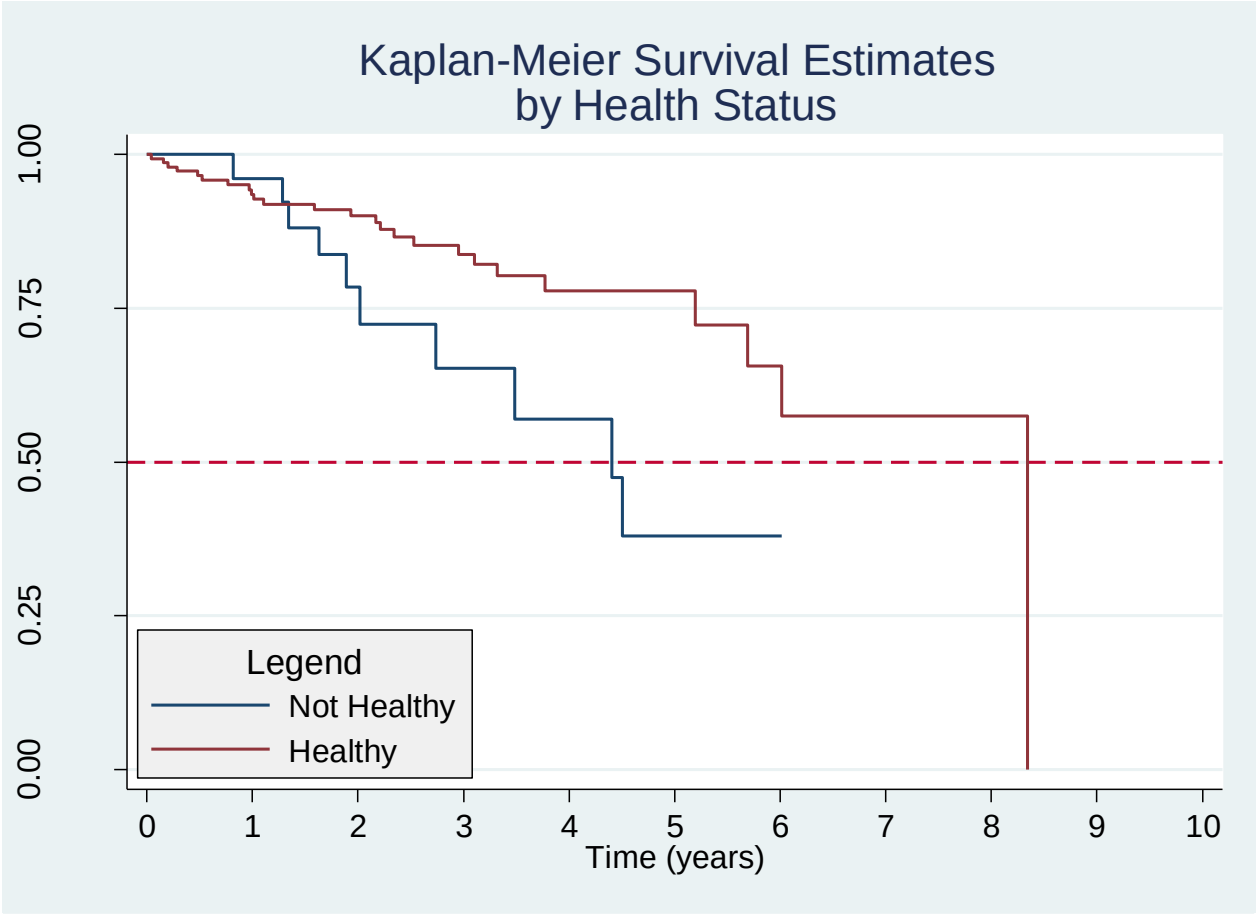

Figure 3. Median Survival Time For Primary Teeth Receiving Interim Therapeutic Restorations (ITR): Comparison Between Healthy vs. Non-healthy Children

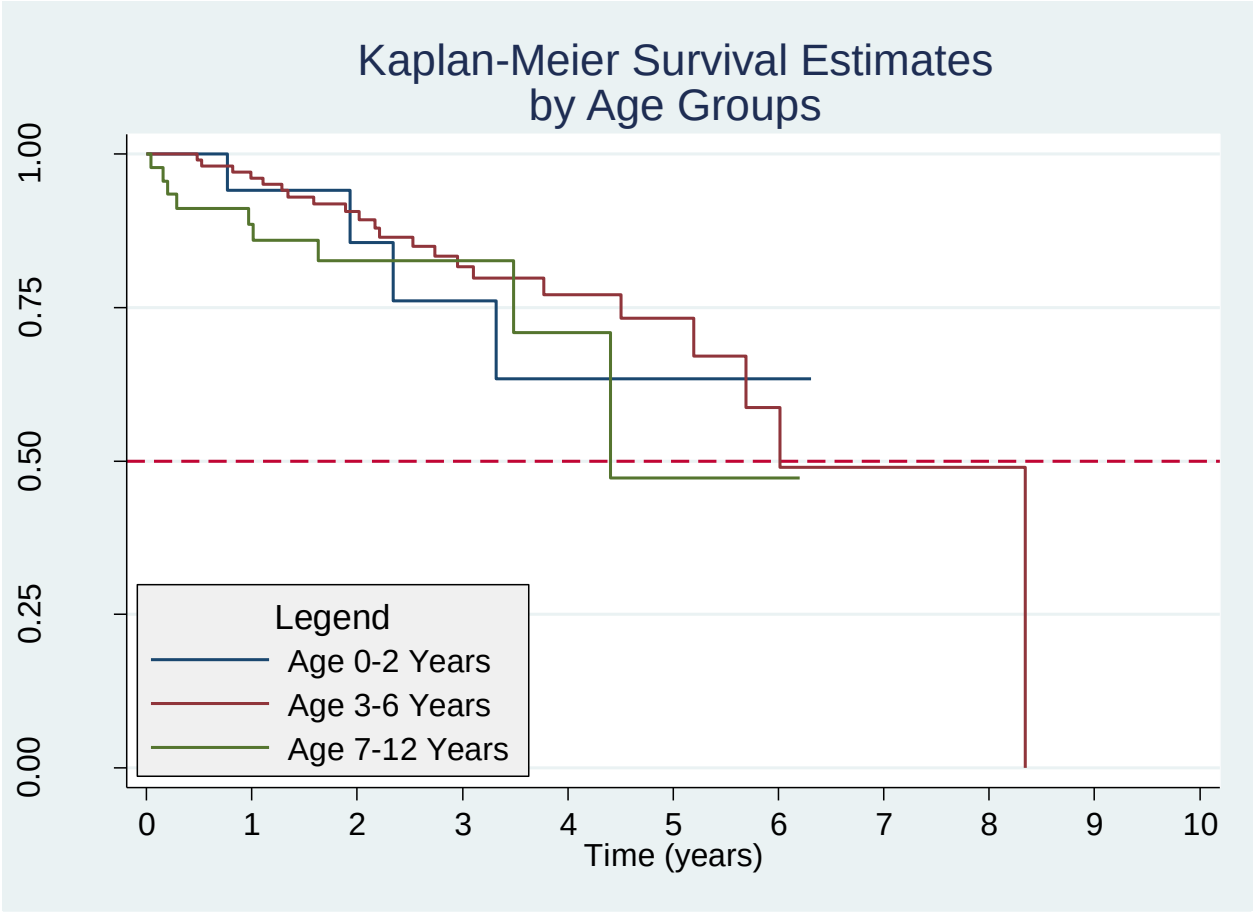

Figure 4. Median Survival Time for Primary Teeth Receiving Interim Therapeutic Restorations (ITR): Comparison Between Age Groups

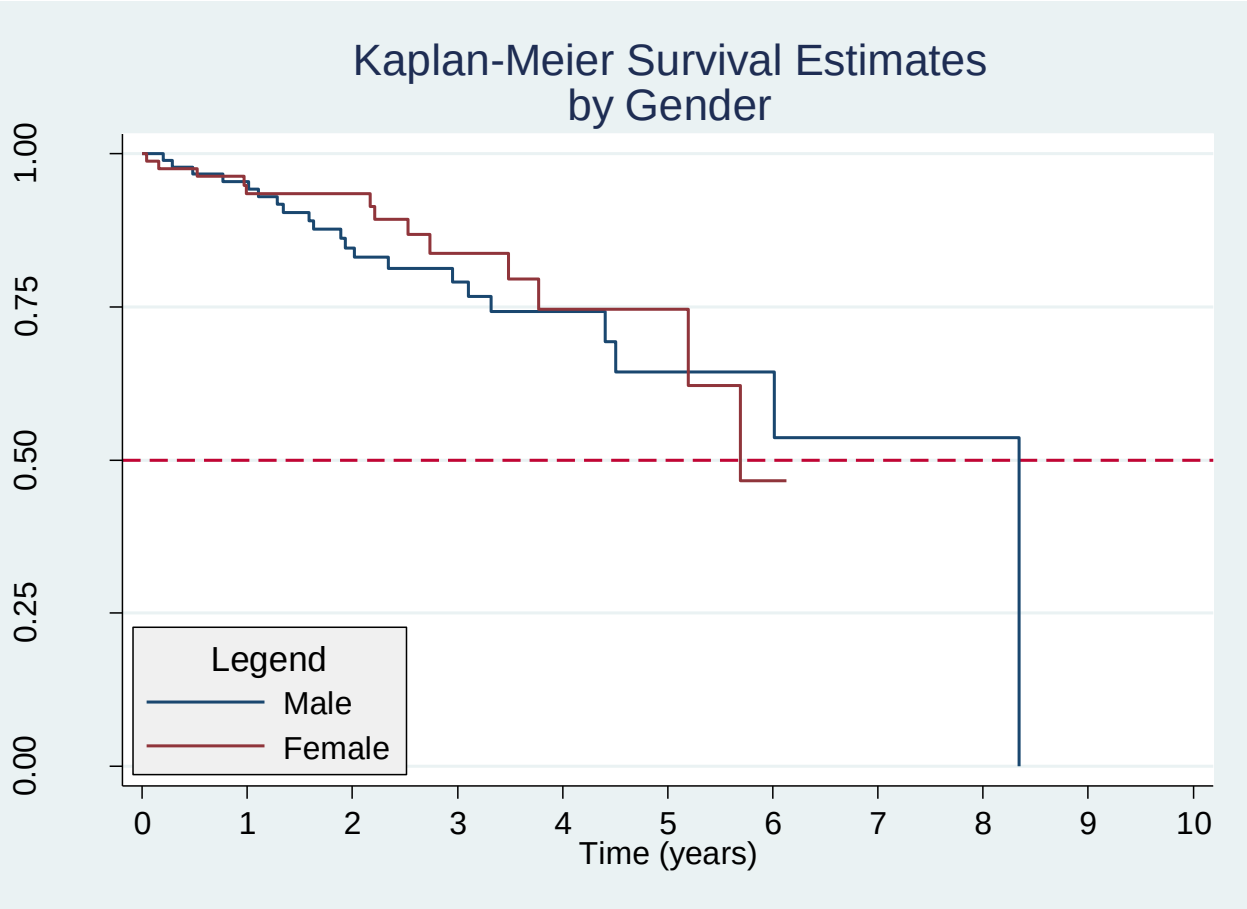

Figure 5. Median Survival Time For Primary Teeth Receiving Interim Therapeutic Restorations (ITR): Comparison by Gender

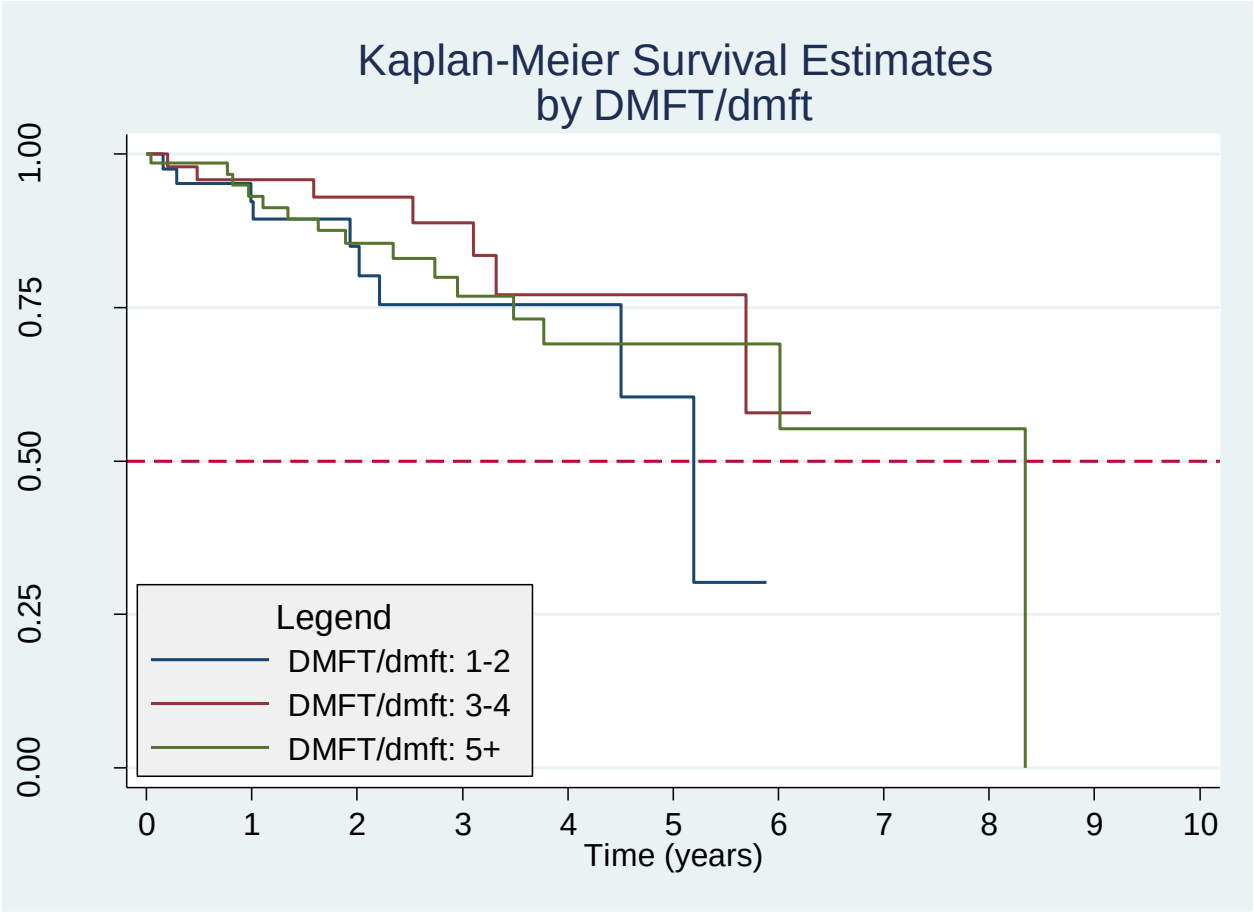

Figure 6. Median Survival Time For Primary Teeth Receiving Interim Therapeutic Restorations (ITR): Comparison by DMFT/dmft

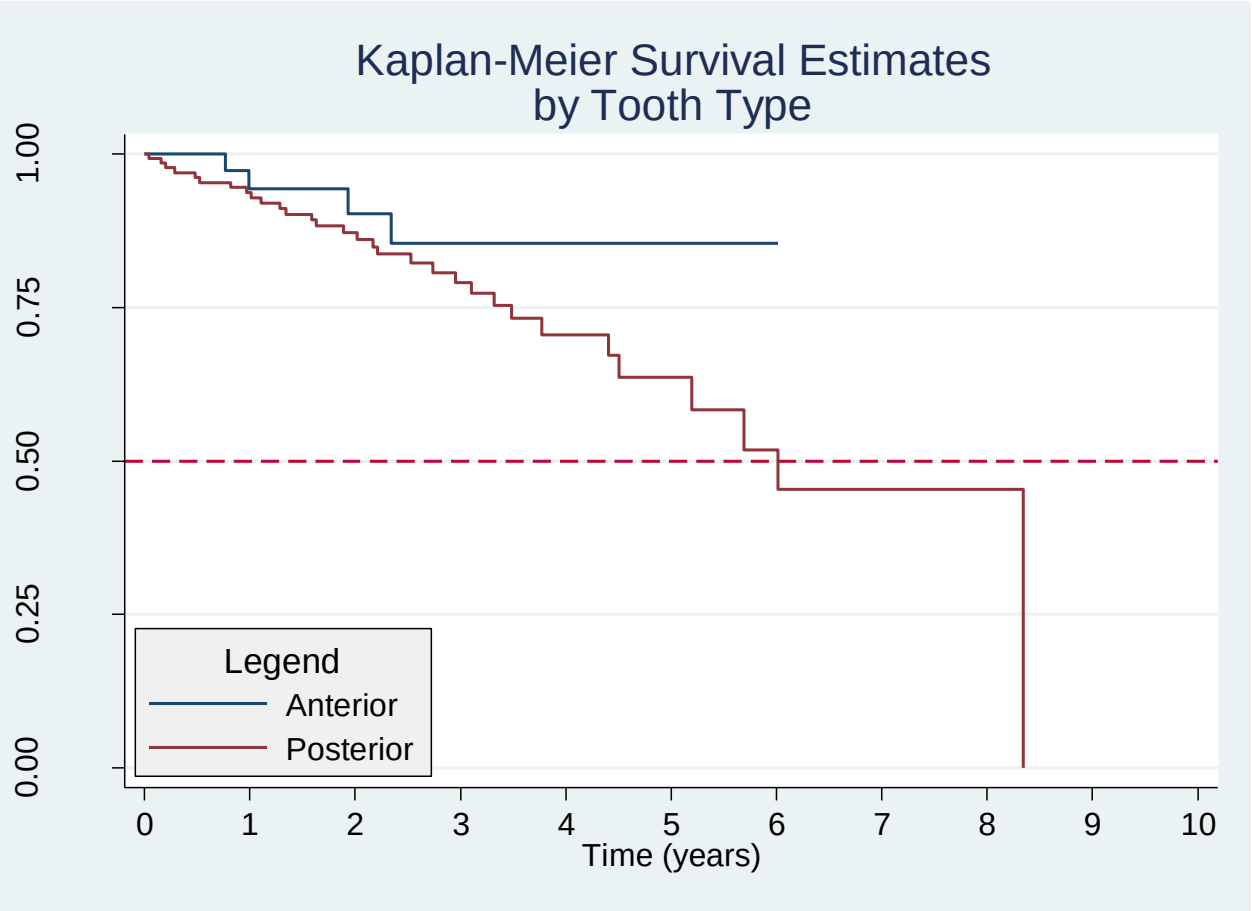

Figure 7. Median Survival Time For Primary Teeth Receiving Interim Therapeutic Restorations (ITR): Comparison by Tooth Type

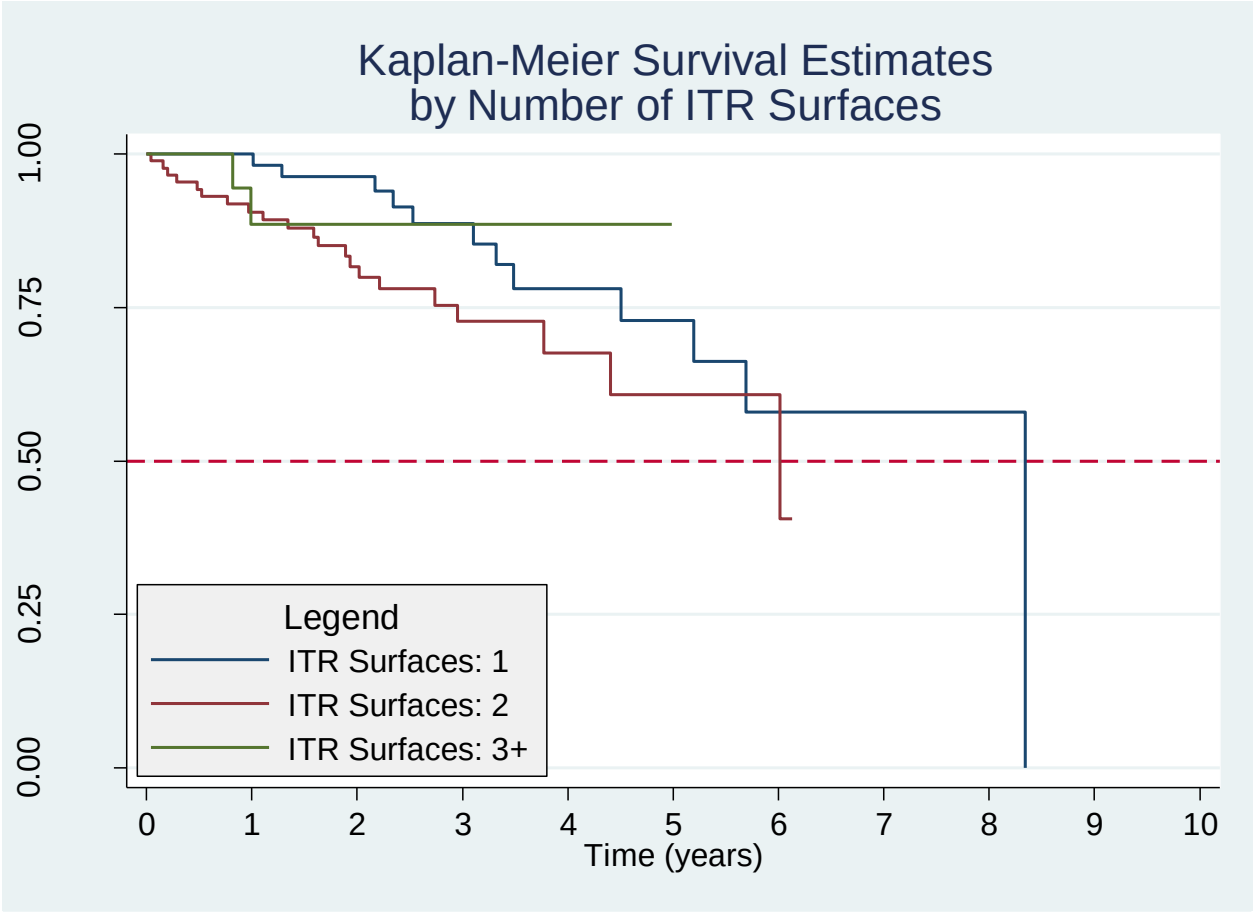

Figure 8. Median Survival Time For Primary Teeth Receiving Interim Therapeutic Restorations (ITR): Comparison by Number of ITR surfaces

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