A retrospective survey of the causes of bracket- and tube-bonding failures

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ABSTRACT

Objective: To investigate the causes of bonding failures of orthodontic brackets and tubes and the effect of premedicating for saliva reduction.

Materials and Methods: Premedication with atropine sulfate was administered randomly. Failure rate of brackets and tubes placed in a group of 158 consecutive patients was evaluated after a mean period of 67 weeks after bonding.

Results: The failure rate in the group without atropine sulfate premedication was 2.4%. In the group with premedication, the failure rate was 2.7%. The Cox regression analysis of these groups showed that atropine application did not lead to a reduction in bond failures. Statistically significant differences in the hazard ratio were found for the bracket regions and for the dental assistants who prepared for the bonding procedure.

Conclusions: Premedication did not lead to fewer bracket failures. The roles of the dental assistant and patient in preventing failures was relevant. A significantly higher failure rate for orthodontic appliances was found in the posterior regions. (*Angle Orthod.* 0000;00:000–000.)

KEY WORDS: Bonding; Brackets; Tubes; Bonding failure; Atropine sulfate

INTRODUCTION

For orthodontic treatment with fixed appliances, it is important that the brackets and tubes be accurately positioned and that the bonding failure rate during treatment be minimized. In this article, the accidental detachment of a bracket or tube during orthodontic treatment will be called "bond failure." Bond failures increase treatment time and lead to direct and indirect costs of orthodontic treatment.[1] In the literature, causes of bond failure such as inefficient drying of the teeth after etching and contamination with saliva are mentioned.[2] After preparation of the dental surface, contamination of the surface with saliva should be avoided. The use of cotton rolls, dry angles, suction,

and cheek retraction are used avoid contamination with saliva during the bonding procedure. To reduce the amount of saliva produced, antisialogogues such as atropine can be effective. Atropine is commonly used to treat certain types of nerve agent and pesticide poisoning and some types of bradycardia, as well as to decrease saliva production during surgery. It is typically given intravenously or intramuscularly. Eye drops are also available to treat uveitis and early amblyopia.The effect of premedication on bond failure has been published.[3,4] As the evidence reported was based on only one study, a prospective, randomized clinical trial was started to evaluate the effect of atropine on bond failure. In the survival analysis, the chance of a bonding failure by administering atropine sulfate before direct bonding and the difference in bonding failure related to bracket position, orthodontist, assistant, and patient will be evaluated.

MATERIALS AND METHODS

Approval of the research protocol was given by the Ethical Committee of the Radboud University Nijmegen, the Netherlands (Approval Nos. 2012/381 and NL41827.091.12). In one private orthodontic office located in Arnhem, a series of consecutive patients who met the inclusion criteria, was semirandomly assigned to the direct bonding of buccally placed orthodontic brackets and tubes in both jaws, with and without atropine premedication. Patients who agreed to

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take part in the research project and met the inclusion criteria scheduled an appointment for fixed appliance placement. Inclusion criteria:

- patients without prior orthodontic treatment,
- complete permanent dentition including the permanent first molars,
- absence of fillings, hypoplasia, buccal or labial white spots, or prosthetic crowns.

Exclusion criteria:

- any contraindication for atropine sulfate medication,
- contact lenses.

Patients bonded during odd-numbered weeks were premedicated with atropine sulfate and those bonded during the even-numbered weeks received a placebo before bonding. Collection of patients started in 2012 during week 21 and finished in week 51. During a follow-up period of 6 months, bracket and tube failures were recorded.

A 0.25% atropine sulfate solution was used as the antisialagogue; however, neither patients nor assistants were aware of a difference in premedication. For patients bonded during the odd-numbered weeks, 2–4 drops of this solution (depending on patient's age and weight) were placed on the tongue 10–20 minutes before start of bonding (atropine group). In the even weeks, patients received 2–4 drops of a pure water solution (control group). After the research period, the solution's content was revealed to one of the authors of this study (T.R.) to permit evaluation of the data.

In this orthodontic office, four dental chairs of the same brand were used for the bonding procedures. Two orthodontists (one with over 20 years of experience and one with over 4 years of experience) and four dental assistants with at least 2 years of experience in the bonding protocol were involved in the bonding procedure for all patients. During this study, each dental assistant used the same dental chair. For all patients included in the study, preparation for bonding was done by a dental assistant using the same materials. All teeth in both arches were cleaned with a nonfluoride toothpaste and pumice solution in a 1:1 ratio. A dry field system, including cotton rolls and dry angles, suction was then applied. Each tooth surface was etched with a 37.5% phosphoric acid gel (ID Blue gel; Ormco, Orange, Calif) for 10–20 seconds. After etching, the gel was removed with water spray and suction. The tooth surface was then dried with clean air.

Only after the planned location for the brackets and tubes appeared chalky white were two layers of primer (Ortho Solo; Ormco) applied to the dental surface. This brand of primer is a universal primer for all bracket adhesives and can be used without a curing light. The orthodontist then applied adhesive (Transbond LR Light Cure Adhesive; 3M Unitek, Monrovia, Calif) to the base of the brackets and tubes (Damon System; Ormco). A first layer of bonding material was pressed onto the bracket base. After a short period, the adhesive acquires a shiny surface after which a second layer is applied to fill in surface irregularities. The bracket or tube was then placed on the tooth surface. Excess bonding material was removed with a dental probe, and light curing of the adhesive for at least 20 seconds followed (UV LED light, 1100–1330 mW/cm^2, 440–445 nm; Demi Ortho, Ormco). The intensity of each curing light was tested every month and adjusted if needed. All first and second molars, when available, were bonded. Any tooth-bracket contacts during occlusion were eliminated with bite or adhesive (Green Glue, Ormco, Orange, Calif). All patients received oral and written instructions on the care and maintenance of the fixed appliances, and regular control visits every 5–6 weeks were scheduled. In the Damon system, heavy forces, which cause binding of the wires, should be avoided.

A new wire was inserted only when the previous wire became inactive. Data on bond failures were collected through patient reports and clinical observation during control visits. Only first-time bond failures were recorded.

Bracket Failures

Patients reported bracket failure immediately to the orthodontic office and an appointment was then scheduled for rebonding. During regular control visits, possible bracket failure was checked, in which case the following remarks were noted:

1. Date of bracket failure
2. Name of dental assistant in attendance during bonding
3. Tooth number on which bracket failure occurred

Statistical Analysis

The SPSS program for statistical evaluation (IBM SPSS Statistics for Windows, Version 20.0; IBM Corp, Armonk, NY) was used to evaluate failure rates. The level of significance was set at P value <.05. A Kaplan-Meier survival curve was made using the R programming language (R Foundation for Statistical Computing, Vienna, Austria). The Cox regression mixed effects procedure was performed in R to evaluate the hazard ratios (HRs) for the following factors: bonding with or without atropine sulfate (atropine group, control group), sex, age, location of failure (anteriors [incisors and canines], premolar region, and molar region in the
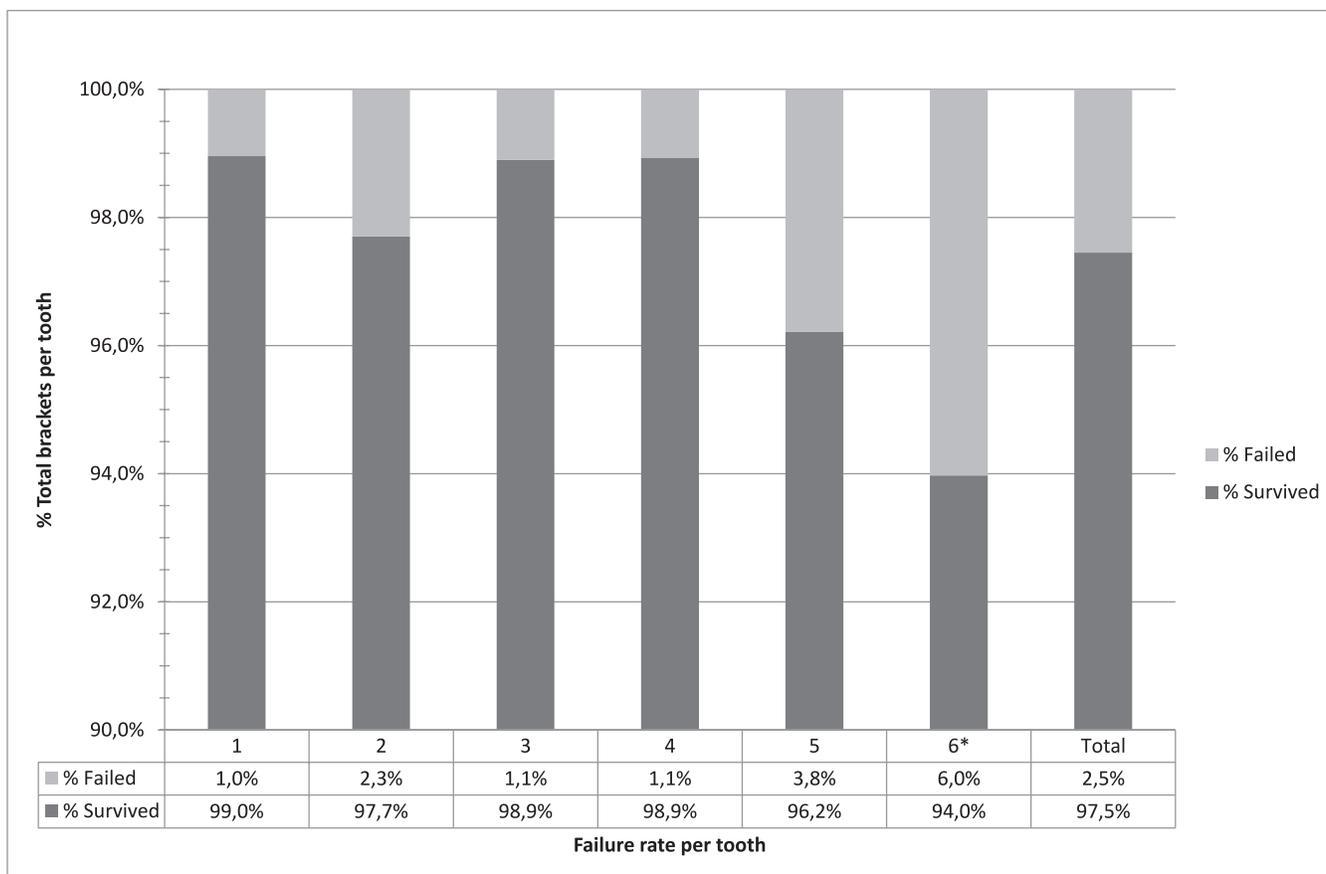
Figure 1. Failure rate (%) per tooth. *Indicates tubes per tooth.

maxilla or mandible), the orthodontist, and dental assistant who was involved in the bonding procedure.[5,6]

RESULTS

A total of 153 of the 158 patients were included in the evaluation 68/72 group A (with atropine), 85/86 group B (control group). In total, N = 3336 brackets were included of the 3856 brackets placed; 39.3% of the brackets were placed in male patients and 60.7% in females, with a mean age of 16.6 (SD ± 10.73) years. The overall failure rate was 2.5% after a mean follow-up period of 67.3 (SD ± 10.7) weeks. The overall failure rate was 1.8% for the brackets and 6.0% for the tubes. Figure 1 shows the failure rate of brackets and tubes per tooth related to the elapsed time after bonding. The Cox regression of mixed-effects models (fitted by maximum likelihood) was used to evaluate the use of premedication, sex, patient's age, operator, and regions of the dentition.[7]

Premedication

Figure 2 shows the Kaplan-Meier survival curve for the atropine group and the control group. The failure rate was 2.7% in the atropine group and 2.4% in the control group (Figure 2).

No statistical difference was found in the HR of bracket failure in the atropine group compared with the control group (HR = 0.81; 95% CI: 0.42–1.55; P = .530).

Sex

No statistically significant difference was found in HR between male and female patients (HR = 0.72; 95% CI: 0.39–1.36; P = .320).

Patient Age

No statistically significant difference was found in HR for patients' age (HR = 1.02; 95% CI: 0.99–1.05; P = .330).

Operator

No statistically significant difference was found in HR for bracket failure between the two operating orthodontists (HR = 0.98; 95% CI: 0.50–1.90; P = .940). Brackets placed by assistant 4 were 2.2 times more likely to fail in a certain time compared with brackets
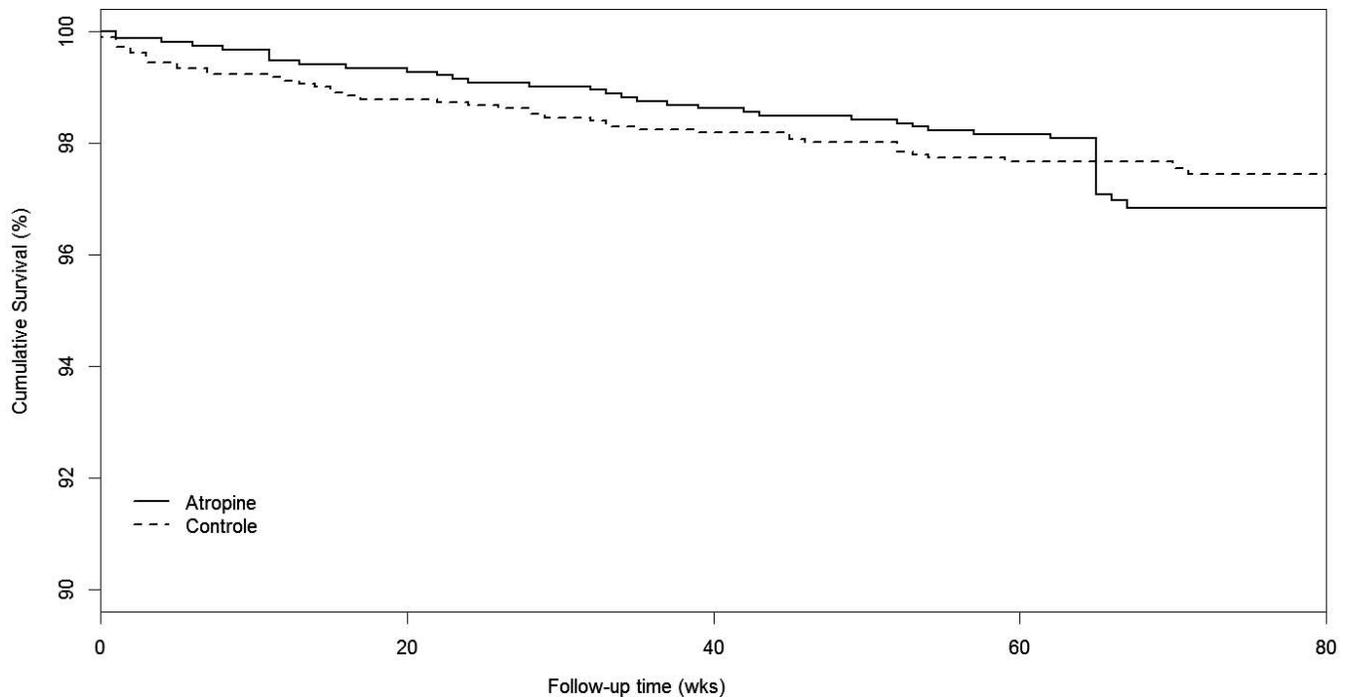
Figure 2. Kaplan-Meier survival curves for the atropine group and control group. *Y*-axis indicates the cumulative survival percentage of the brackets. *X*-axis indicates the follow-up period in weeks.

placed by assistant 1 (HR = 2.21; 95% CI: 1.04–4.07; *P* = .041) and 3.7 times more likely to fail in a certain time compared with assistant 2 (HR = 3.69; 95% CI: 1.52–8.99; *P* = .004).

No statistically significant differences were found in the HR of other assistants. Figure 3 shows the Kaplan-Meier survival curves for each assistant.

Regions

Figure 4 shows the Kaplan-Meier survival curves for the evaluated regions. Maxillary molar tube failure was 2.5 times that of brackets on the mandibular anteriors (HR = 2.49; 95% CI: 1.15–5.37; *P* = .020), 4.2 times that for brackets on the maxillary anteriors (HR = 4.18; 95% CI: 1.68–10.42; *P* = .002), and 2.4 times that for brackets on the maxillary premolars (HR = 2.43; 95% CI: 1.01–5.89). These differences are statistically different.

The rate of mandibular molar tube failure was 4.5 times that of brackets on the mandibular anteriors (HR = 4.48; 95% CI: 2.39–8.40; *P* < .001) and 7.5 times that of the maxillary anteriors (HR = 7.53; 95% CI: 3.32–17.04; *P* < .001). The rate of mandibular molar tube failure was almost 3 times that of the mandibular premolar brackets (HR = 2.98; 95% CI: 1.59–5.60; *P* = .001) and 4.4 times that of the maxillary premolars (HR = 4.38; 95% CI: 2.00–9.57). These differences are statistically significant, as were differences found in the HR for bracket failure on the mandibular premolars

compared with the maxillary anteriors (HR = 2.52; 95% CI: 1.07–5.92; *P* = .034). No statistically significant differences were found in other regions.

DISCUSSION

In the literature, we found bond failure percentages between 1.2% and 8% for brackets bonded using the direct technique.[2,3,8] For molar tubes, bonding failures between 10.6% and 13.8% were reported.[2,8] It is difficult to compare outcomes of our study with previously published studies as their materials and methods were different. However, failure rates found in this study are within the range of previously published failure rates. A minimum observation period of 6 months for bracket failure was chosen as it was reported that 82% of bracket failures occur during that period.[5,6] Bracket failure in this study occurred during the whole observation period. It can be questioned whether a bracket failure that occurs more than 3 months after bonding is caused by the bonding procedure.

The finding that bonded tubes failed more often than brackets on premolars, canines, and incisors is in concordance with a previous study.[9] In the Maijer and Smith study, the 12-month failure rates of incisor, canine, premolar, and molar brackets were, respectively, 3.6%, 1.6%, 4.8%, and 11.6%, and it was reported that there was no significant difference in bond failure between the first and second molar.[10] In
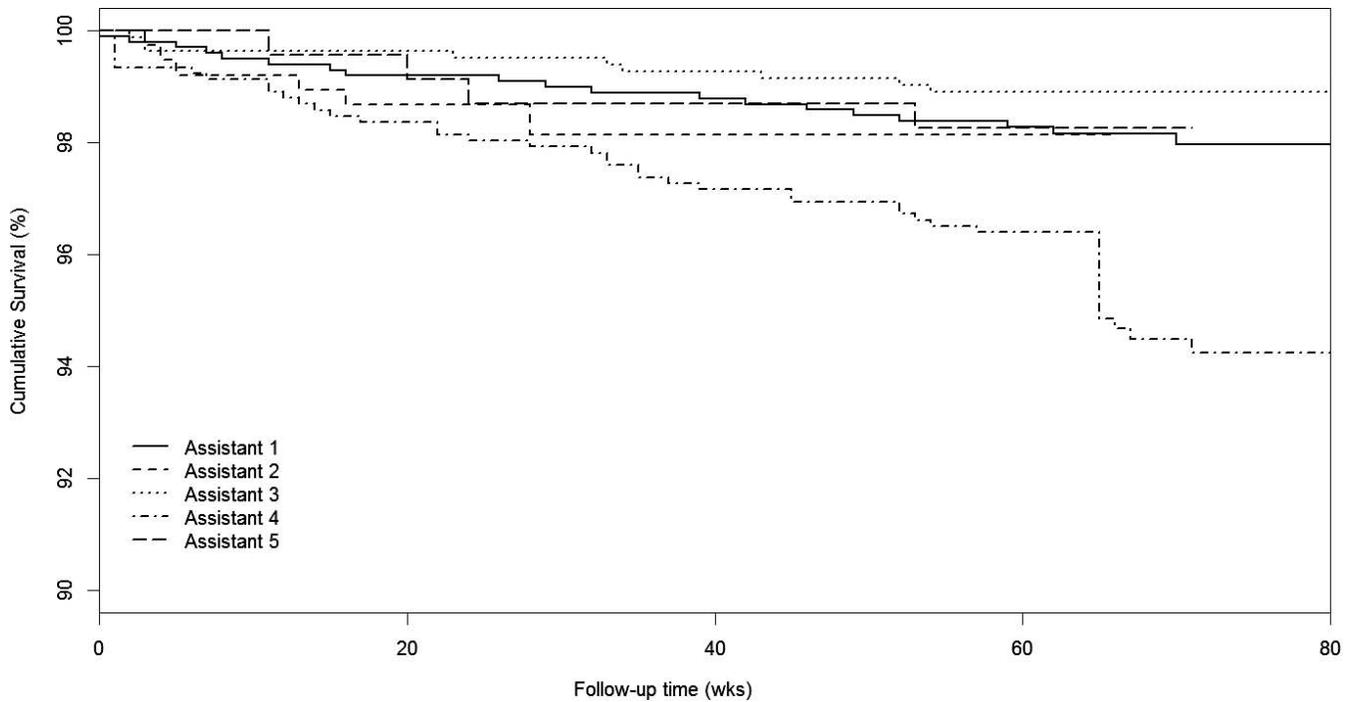
Figure 3. Kaplan-Meier survival curves for dental assistants. *Y*-axis indicates the cumulative survival percentages of the brackets. *X*-axis indicates follow-up period in weeks.

our study, all second molars were bonded when the buccal surface was suitable for bonding, and a total of 394 tubes were bonded on these teeth. If we had included only patients having tubes bonded on all

second molars, the impact of this study would be much lower. Furthermore, only the failure of the first molars is relevant for comparing the results with previous studies. Of the 394 tubes placed on second molars, a
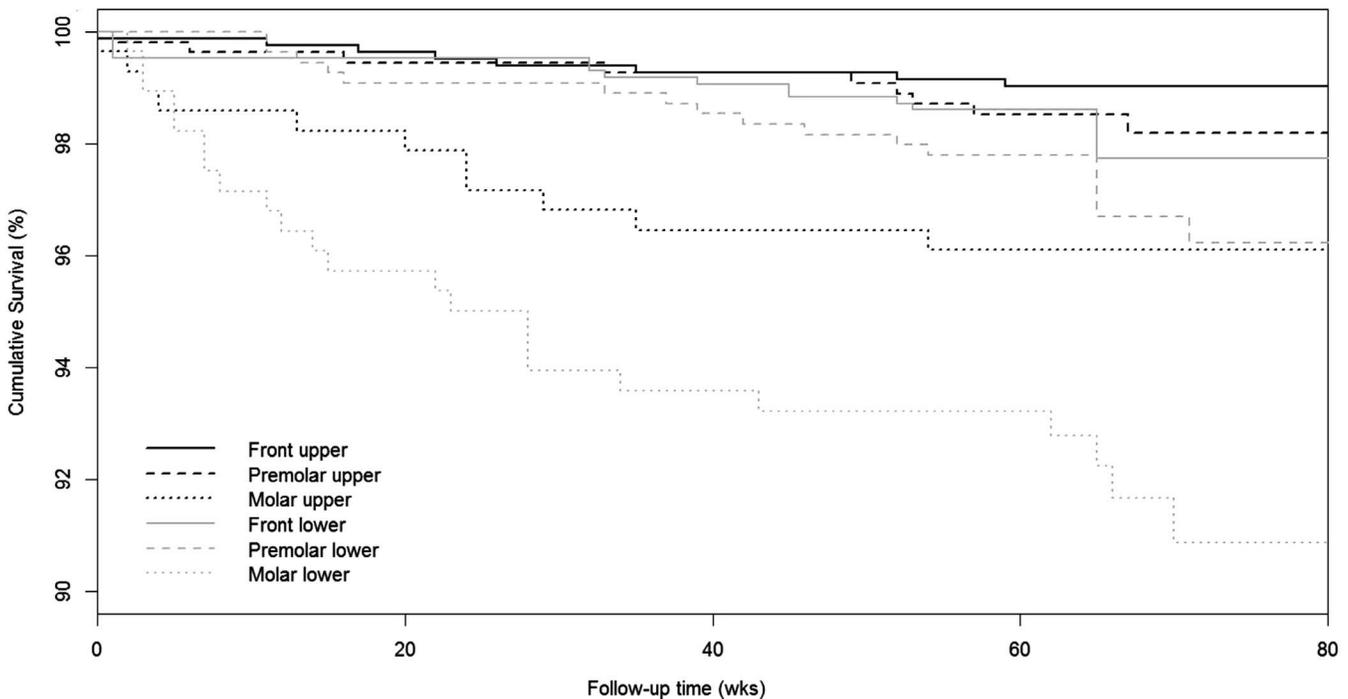

Figure 4. Kaplan-Meier survival curves for the maxillary anteriors, maxillary premolars, maxillary molars, mandibular anteriors, mandibular premolars, and mandibular molars. *Y*-axis indicates cumulative survival percentages of the brackets. *X*-axis indicates follow-up period in weeks.

10.7% failure rate was recorded. If the first molars had been included, a total failure rate of 7.9% of 958 molar tubes would be found. If bonding failures of second molars are included in the Cox regression analysis, more statistically significant differences are found. Male patients had twice the chance of a bond failure than did female patients (HR = 1.72; 95% CI: 1.05–2.81; P = .030).

Maxillary molars had 2.8 times the chance of having a bond failure compared with mandibular premolars. Also, statistically significant differences were found in the HR of maxillary molars (HR = 2.85; 95% CI: 1.57–5.21; P < .001) compared with mandibular premolars.

In the literature it, was reported that the failure rate of first molar bands varied from 34.6% to 0.56%.[10,11] Evaluating the results of our study, we conclude that bonding tubes on first and second molars can be an alternative for banding without increasing the risk of failure. A relation between age and bond failure was not found. Other reports mention that in young patients (age <18 years), a higher failure rate was found than for older patients (>18).[9] According to the failure rate and the use of atropine sulfate for premedication, it was expected that the antisialogogue would reduce contaminating the tooth surface with saliva after preparation for bonding. In Pondouri's study of a split-mouth design (one arch was bonded with premedication and the other without), it was found that atropine premedication did not lead to a reduction in bracket failures.[3] A drawback of this study design was that the patients administered the atropine themselves. It can be speculated that the ineffectiveness of the atropine in our study was caused by an insufficient time span between application of the atropine solution and start of the bonding procedure (10–20 minutes). This time span was chosen arbitrarily and could have been too short to be effective. Another explanation might be that the effective use of cotton rolls, dry angles, and suction during bonding prevented saliva contamination of the tooth surface.

We found that bond failure was higher if assistant 4 was involved and was independent of which orthodontist positioned the brackets. It can be speculated that bond failure is related to the preparation of the tooth surface, curing of the adhesive, and the measures taken to prevent bracket-tooth contact. After bracket failure, the location of residual adhesive was registered, but we were unable use these data to come to any significant conclusion. As each assistant worked at the same respecting chairs during the study, a mechanical problem in the dental chair, curing light, or suctioning by assistant 4 should be taken into consideration. The finding that the failure rate of posterior brackets and tubes was significantly higher than in the anterior region has been reported previously. These authors concluded that the mean survival time for brackets in incisors was

statistically higher than the failure rates of canines and premolar brackets.[2,12] The higher bond failure rate for first and second molar tubes can be related to the difficulty of avoiding contamination, manipulation of the tube during bonding, and higher forces of mastication in the molar region.[13] In an investigation using a sample size of 128 patients, no significant difference between bracket failure rates of incisors vs premolars was found.[8] In our study, we found a significantly higher failure rate for orthodontic appliances in the mandible compared with the maxilla. This finding has been mentioned in other studies, but in this study, the difference was not statistically different.[2] As we found that 30% of bracket failures occurred in about 10% of the patients, the role of the patient in bracket failure is significant. As an alternative to direct bonding, an indirect bonding procedure for bracket placement can be used. Especially for lingual orthodontics, indirect bonding has become the method of choice. The failure rate for indirect bonding of brackets and tubes has been found to be the same as or somewhat higher than that of direct bonding.[13] Even if the direct method should result in fewer failures, indirect bonding has several advantages:

- more accurate bracket placement,
- dental assistants can position the indirect bonding trays,
- a significant reduction of chair time,
- reduced need for rebonding of brackets during treatment,
- because of the above, total treatment time can be shorter.

Further research is needed to study the advantages and disadvantages of direct and indirect bonding so that the most effective method of bonding orthodontic appliances can be found.

CONCLUSIONS

- The use of atropine premedication to reduce saliva during direct bonding of orthodontic brackets and tubes did not lead to fewer bracket failures.
- The role of the dental assistant in an effective bonding workflow is important.
- A significantly higher failure rate for orthodontic appliances in the posterior regions of the mandible and maxilla was found.

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