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# A Clinical Retrospective Evaluation of 2 Orthodontic Band Cements

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**ABSTRACT**

This study aimed to compare the time to first failure of stainless steel orthodontic first permanent molar bands cemented with either a modified composite (Band-Lok, Reliance Orthodontic Products) or a conventional glass ionomer cement (AquaCem, De Trey Dentsply). The effect of patient sex, patient age at the start of treatment, the presenting malocclusion, treatment mechanics, and the operator proficiency on band survival was also assessed. Data for 219 bands cemented with Band-Lok in 108 patients and for 395 bands cemented with AquaCem in 183 patients were analyzed. For each case, a single molar band, either the band that was first to fail or the band that had the shortest follow-up time, was chosen for analysis. For each cement, whether headgear was used or not, there was no significant difference in time to first band failure ($P$ = .398). Twenty-six percent of patients had at least one band failure with Band-Lok, and 30% of patients had at least one band failure with AquaCem, representing an 18% band failure rate for each cement. There was no significant difference in time to first band failure for either cement with respect to sex of the patient ($P$ = .842), patient age at the start of treatment ($P$ = .257), presenting malocclusion ($P$ = .319), or operator proficiency ($P$ = .062). The use of headgear, however, reduced significantly the time to first band failure irrespective of cement type ($P$ = .0069). Headgear use was identified as a predictor of first permanent molar band survival. Clinical performance of bands cemented with either cement appears to be similar and was influenced significantly by the use of headgear.

**KEY WORDS:** Clinical review, Band cements, Survival analysis.

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## INTRODUCTION Return to TOC

Although bonding of orthodontic attachments is now undertaken routinely as part of fixed appliance therapy,[1,2] metal bands continue to be cemented to molar teeth. Bands afford a reduced failure rate over bonded attachments posteriorly in the mouth.[3,4] Band retention is achieved mechanically by its close adaptation to the tooth surface assisted by the cement lute.[5] Zinc phosphate cements were used widely for band cementation in the last century.[6,7] However, these cements have relatively high solubility intraorally and fail to bond chemically with either stainless steel or enamel, relying entirely on mechanical means for their retentive effect.[8,9]

To overcome these weaknesses, other dental cements have been developed. Although polycarboxylate cements, which react chemically with enamel and stainless steel, were found to be suitable clinically for band cementation,[10,11] their short setting time and high viscosity reduced their popularity.[9,12]

Glass ionomer cements, introduced in 1971, are now in widespread use for band cementation.[13] True adhesion to enamel and metal,[14] probably via ionic or polar molecular interactions,[15] plus the ability to release[16] and absorb[17] fluoride make these materials particularly attractive as orthodontic band cements. A reduced band failure rate[18–20] and less enamel decalcification underneath the band[19,21] have been observed clinically when bands have been cemented with glass ionomer rather than zinc phosphate cement. Significant differences in failure rates, however, have been reported by clinicians using conventional glass ionomer cements for band cementation.[22] Although many factors may account for this interpractitioner variability, it is likely to be accentuated by differences in powder/liquid proportioning[23] and moisture contamination during the setting reaction, as these cements take up to 24 hours to reach their maximum strength.[24]

Modifications in cement formulation by the addition of resin allow light-curing, a snap set, and rapid strength development.[25] In addition, marketing the cement in a 2-paste, 1-paste, or encapsulated form is likely to lead to a more consistent and reproducible cement mix because powder-liquid proportioning is eliminated. However, as wide variability exists among resin-modified glass ionomer materials with respect to the chemical constituents and setting reaction of individual products, variability also exists regarding their nomenclature.[26] These products have been categorized as either modified composites or true resin-modified glass ionomer cements. The former are essentially resin-matrix composites, the filler having being replaced by an ion-leachable aluminosilicate glass. Setting occurs via free radical polymerization of methacrylate groups (often light activated), and there is no acid-base reaction.[24,26] Resin-modified glass ionomer cements, on the other hand, are based on a hybrid of their two parent groups and are often provided in encapsulated form with an acid-base reaction included in their setting.[26]

A modified composite has been shown to have comparable clinical performance to a conventional or a resin-modified glass ionomer cement for band retention[27] but exhibits less in vitro fluoride release than the other two cements.[28] However, in the study by Fricker,[27] only 62 bands were cemented with a modified composite, 57 bands with a conventional glass ionomer cement, and 69 bands with a resin-modified glass ionomer cement. These represent modest sample sizes per cement group, and the observation time was only 12 months. Data from a larger sample would be required to give clearer perspective with respect to band performance with each of these newer cements.

Several studies[18–20,22,27] have reported on the clinical failure rate of bands cemented with the conventional glass ionomer cement Ketac-Cem (Espe, Gmbh, Seefeld/Oberbay, Germany), but no study appears to have documented the performance of bands cemented with another conventional glass ionomer cement, AquaCem (De Trey Dentsply, Konstanz, Germany). In addition, the survival pattern of bands cemented with that cement has not been compared with that of bands cemented with a light-cured modified composite, Band-Lok (Reliance Orthodontic Products Inc, Itasca, Ill). Furthermore, no study has examined comprehensively the effect of patient variables, treatment mechanics variables, and operator variables on the clinical performance of bands cemented to molar teeth with either of these cements, nor has an attempt been made to identify predictors of band survival with either luting agent.

The aim of this retrospective study was to compare the time to first failure of first permanent molar bands cemented with either Band-Lok or AquaCem. The effect of the patient's sex and age at the start of treatment, the presenting malocclusion, treatment mechanics, and operator proficiency on band survival was also assessed.

## MATERIALS AND METHODS Return to TOC

AquaCem has been used in the Orthodontic Department of the County Hospital, Halmstad, Sweden, since 1988 for routine cementation of orthodontic bands in patients undergoing fixed appliance therapy. Since 1994, Band-Lok has also been used for band cementation. The choice of cement for band cementation has been made by the clinician undertaking orthodontic treatment.

The record files of patients completing fixed appliance orthodontic treatment at this unit between January 1, 1995, and July 31, 1998, inclusive were examined. Only cases in which all first permanent molar bands were cemented with either AquaCem or Band-Lok were selected. Cases involving headgear and/or palatal/lingual arches were included. Two trained orthodontic hygienists with at least 2 years postqualification experience and four orthodontists with many years experience were responsible for cementing the molar bands. When appropriate, teeth were separated before banding with elastomeric separators (Ormco Corp, Glendora, Calif). After separator removal, the teeth were cleaned with a nonabrasive liquid (Tubilicid, Dental Therapeutics, Nacka, Sweden) and washed with water.

Optimally sized stainless steel bands (Ormco Corp) were selected for each first permanent molar. These teeth were dried in a stream of compressed air and isolated with cotton wool rolls and a high-vacuum saliva ejector. AquaCem or Band-Lok was mixed according to manufacturer's instructions and applied to completely cover the fitting surface of the band. The band-fitting surface was not roughened before application of either cement. After band placement, excess cement was removed with a cotton wool roll. Isolation was maintained on teeth on which bands were cemented with AquaCem until the cement had set on the mixing pad. When Band-Lok was used for band cementation, it was light cured for 60 seconds from the occlusal aspect of the banded tooth with a dental curing light (3M Unitek, Monrovia, Calif). The two dental hygienists cemented most of the bands when Band-Lok was used as the luting agent.

An 0.018-inch preadjusted edgewise system (Ormco Mini Diamond brackets, Ormco Corp) was used in each case, with all brackets applied with a light-cured resin adhesive, Transbond (3M Unitek). Initial aligning archwires were either 0.010-inch or 0.012-inch stainless steel wires (TP, La Porte, Ind. USA) or 0.0155-inch Dentaflex wires (Dentaurum, Pforzheim, Germany). These wires were tied into the brackets and bands immediately after completion of bracket bonding. Verbal and written instructions regarding appliance care were issued to each patient with a specific request to return if any component became loose, or if any problem arose. In cases in which headgear (Ormco Corp) was employed, it was tried on and adjusted for fit 10 to 15 minutes after band cementation. An occipital pull headgear that incorporated a safety mechanism was used. Headgear was applied to the bands, for a specified duration, 5 to 10 hours after cementation, and in most cases an orthopedic force was used. Throughout treatment, each patient was rechecked at 4- to 6-week intervals, and any band failure (identified as band loosening) was recorded accurately in the patient's case notes. The time of band failure was recorded as the appointment date on which band loosening was discovered.

For each patient, the following information was recorded: date of birth and sex of the patient, presenting malocclusion based on the Angle classification, date of placement of each first permanent molar band including cement type used, type of treatment mechanics, the operator, and the fate of each band up to July 30, 1998.

A code was allocated to each band to indicate if the band survived the course of treatment (censored, code 1), the patient had moved away (withdrawn, code 2), or the band had loosened (failed, code 3). Formal analyses were undertaken using SAS for Windows, version 6.12 (SAS Inc, Cary, NC) on a single band per patient as the analyses assume that the observations are all independent of one another. For each case, the band chosen was the band that failed first. In cases in which no band failed, the band with the shortest follow-up time was analyzed and handled as a censored observation in the formal analyses. For each cement, the effect of patient sex, patient age at the start of treatment, the presenting malocclusion, treatment mechanics, and operator proficiency on band survival was assessed by producing Kaplan-Meier estimates of survival curves stratified by the factor. The log-rank test was used to compare the various levels of the factor (eg, to assess whether band survival differed for male and female patients). In addition, relative hazards were calculated based on a Cox proportional hazards model to compare various subgroups. A relative hazard of 1 indicates that there was no difference in failure rate between two subgroups, whereas a relative hazard of two indicates a 2-fold difference in failure rate between one group and another.

## RESULTS Return to TOC

### Survival Analyses of the Various Factors: Univariate Analyses

*Effect of cement.* The sample characteristics for patients in which bands were cemented with either Band-Lok or AquaCem are given in Table 1. No bands failed in 209 patients, whereas at least 1 band failed in 82 patients. Analyses of those patients who suffered only 1 band failure indicated that the upper left was the most frequent position for failure, recording 35 failures, with 30 failures recorded for the upper right, four for the lower right, and none for the lower left.

When analyzing time to first failure only, 28 bands cemented with Band-Lok failed, while 54 bands cemented with AquaCem failed. Twenty-six percent of patients had at least one band failure with Band-Lok, and 30% of patients had at least one band failure with AquaCem, representing an 18% band failure rate with each cement.

Figure 1 shows the Kaplan-Meier estimate of the overall survival curves for each cement. The numbers at risk are the number of patients in whom bands had not failed at that time. The median band survival time (time until first band failure) was 1022 days for Band-Lok but was inestimable for bands cemented with AquaCem, as the curve never went below 50%. No evidence was found of a difference in band survival for bands cemented with either Band-Lok or AquaCem ($P$ = .398; relative hazard for AquaCem compared with Band-Lok: point estimate, 1.22; 95% confidence interval, 0.77 to 1.92).

*Effect of patient sex.* No evidence was recorded to indicate a difference in band survival for male or female patients (Figure 2) ($P$ = .842; relative hazards for male patients compared with female patients: point estimate, 0.96; 95% confidence interval, 0.62 to 1.48).

*Effect of patient age at the start of treatment.* Age at the start of treatment was a continuous measurement and was divided into categories to allow survival curves to be drawn (Figure 3). The data were split at quartiles ensuring four equally sized groups for comparison. Analyses of the four different age groups indicated no evidence of a difference in band survival for each of the subgroups ($P$ = .257; relative hazard per 1-year advance in age at the start of treatment: point estimate, 0.91; 95% confidence interval, 0.82 to 1.02).

*Effect of presenting malocclusion.* There were four malocclusion groups included in the study. No evidence was recorded to indicate a difference in band survival for the four malocclusion types (Figure 4) ($P$ = .319). There were, however, few patients in the study who had either Class II division 2 or Class III malocclusion. The study, therefore, may not indicate fully the performance of each cement within these two groups.

*Effect of treatment mechanics.* There were four treatment mechanics groups and an ‘other’ group in which patient data were unavailable; the latter group was excluded from this subgroup analysis. Two separate types of analyses were undertaken: one comparing patients split into four subgroups for analyses (Table 1) and one comparing patients who received headgear (alone or in combination with palatal arch) with the other groups. There was a significant difference in band survival between those cases with headgear alone compared with those without headgear or palatal/lingual arch/quadhelix (*P* = .0069; relative hazard for patients who wore headgear compared with patients who did not wear headgear: point estimate, 2.31; 95% confidence interval, 1.26 to 4.24). The failure rate was 19% in the group in which bands were cemented with Band-Lok and not subjected to headgear or palatal arch, but the failure rate was 33% when headgear alone was applied. When AquaCem was used, 24% of bands failed without headgear application, and 44% of bands failed when headgear was used. For the combination palatal arch/lingual arch/quadhelix groups compared with those who did not wear these appliances or headgear appliances, the increase in risk of band failure was not significant (*P* = .2911; point estimate, 1.57; 95% confidence interval, 0.68 to 3.63; and *P* = .9376; point estimate, 1.03; 95% confidence interval, 0.51 to 2.09, respectively). For the purposes of clarity of presentation, Figure 5 amalgamates the data from the two subgroups involving headgear (ie, headgear alone and headgear with palatal arch) and compares these with data from all remaining subjects (ie, the no headgear group). This subgroup amalgamation was also used in the multivariate analysis.

*Effect of operator.* There were six operators involved in the study. There was no evidence of a difference in band survival for different operators (Figure 6) (*P* = .062).

### Multivariate Analyses

Comparing cement types and adjusting for headgear, no significant difference was found in band survival pattern for either cement (*P* = .1153; relative hazard for patients with AquaCem compared with those with Band-Lok adjusting for headgear: point estimate, 1.46; 95% confidence interval, 0.91 to 2.32). However, headgear use was significantly predictive of band survival for each cement (*P* = .0009; relative hazard for patients wearing headgear or headgear/palatal arch vs those in any other treatment mechanics group adjusting for cement type: point estimate, 2.16; 95% confidence interval, 1.37 to 3.40). As no statistically significant interaction was found between the effects of headgear and the cement used, headgear use would appear to be predictive of band survival irrespective of the cement type.

## DISCUSSION Return to TOC

The time to first failure of 219 bands cemented with Band-Lok and 395 bands cemented with AquaCem was assessed. In the majority of patients (89%), only two bands were cemented. The explanation for this is that bonding tubes to molars, rather than using band cementation, has been standard practice in the department for more than a decade. The data on bonded molar tubes have been analyzed and reported previously.[4] Banding molars is selected mainly when palatal/lingual arches or extraoral force is used and when potential occlusal trauma to a bonded attachment is deemed likely by the operator.

Reports on the clinical performance of orthodontic band cements have been presented primarily in terms of band failure rates. Few studies[20,22,29] have used survival analysis for statistical handling of the data. They have thereby failed to obtain important additional information on the time to first band failure and have also failed to fully appreciate the effect of several independent variables on band survival or the possibility of identifying predictors of survival.

### Overall Analysis

In the present study, 30% of patients had at least 1 band failure when bands were cemented with the conventional glass ionomer cement AquaCem. This represents a failure rate of 18% and includes those bands to which headgear was applied. There appear to be no other published accounts of band failure rates with this cement to which direct comparison can justly be made. However, an appraisal of the studies[29] in which another conventional glass ionomer cement, Ketac-Cem, has been used for first molar band cementation revealed failure rates ranging from 0% to 26% although the observation time varied considerably between studies, making comparison difficult. An 8.1% failure rate has been reported over 12 months for bands cemented to first permanent molars with Band-Lok.[27] In the present study, however, 26% of patients who had bands cemented with that cement had at least one band failure. This indicates an 18% failure rate and is inclusive of bands subjected to headgear forces. Roughening of the band-fitting surface with a diamond bur before cement application[27] is likely to account in part for the differences in outcomes between these studies, and sandblasting has been previously shown to significantly reduce band failure rates.[29] Interestingly, Fricker[27] found no significant difference in failure rate between bands with roughened fitting surfaces cemented with Ketac-Cem or Band-Lok, and the current study found no significant difference either between failure rates for bands with untreated fitting surfaces cemented with AquaCem or Band-Lok. Although these cements have completely different mechanisms of adhesion, their clinical performance with respect to band retention rates was similar. AquaCem relies on integration with hydroxyapatite, whereas Band-Lok locks mechanically to metal but inadequately to nonetched enamel.

The median survival time of bands cemented with Band-Lok was 1022 days or almost 34 months, but it was not possible to calculate equivalent outcomes for bands cemented with AquaCem because the survival curve for this cement did not drop below 50%. There was, however, no statistically significant difference in time to first band failure with either cement. Although the failure rate was similar with each band cement, the pattern of failure appeared to differ between them, with an accelerated rate of failure with AquaCem relative to Band-Lok particularly noticeable at 12 and 18 months (Figure 1). Interestingly, this pattern reflects the survival pattern observed in vitro, after application of simulated mechanical stress to bands cemented with Ketac-Cem or Band-Lok.[30]

### Impact of Individual Factors on Band Survival

No significant difference in band failure rate has been observed previously between male and female patients, irrespective of whether bands were cemented with zinc phosphate,[6] zinc polycarboxylate,[11] or glass ionomer cement.[22,31] The findings of the present study support those of studies in which glass ionomer cement was used as the band luting agent and also indicate no apparent sex bias for band failure with the modified composite.

When bands are cemented with either zinc phosphate[6] or glass ionomer cement,[22] a higher band failure rate has been recorded in individuals in early teenage years than in individuals in later teenage years, but this pattern was not observed in the study presented here. The narrow age range of the study sample (12 to 14 years) is likely to account for this. A sample with a more diverse age distribution with greater numbers of patients in subgroups outside of this age range would be required to assess objectively the likelihood that patient age at the start of treatment has a significant effect on time to first band failure for the cements evaluated here.

It appears that the impact of the presenting malocclusion on first permanent molar band survival has not been analyzed critically in any previous study. In this study, band survival did not differ significantly among the malocclusion classes. The number of cases per malocclusion class, however, was not equal, with all but six cases categorized as either Class I or Class II division 1 malocclusion. Therefore, the results are only meaningful with respect to these subgroups. Any intergroup differences involving Class II division 2 or Class III malocclusion would be insensitive because of the lack of sufficient data. A larger sample of patients distributed evenly among Class II division 2 malocclusion and Class III malocclusion would be required to provide robust data necessary to examine the possibility of any real difference in band survival between each of the 4 malocclusion classes.

The effect of treatment mechanics on band survival has been assessed in previous studies.[10,11,22,29] Although conventional glass ionomer cement may take up to 24 hours to reach its maximum strength,[24] headgear forces were applied to bands, for a specified therapeutic duration, 5 to 10 hours after cementation. This may account for the 44% failure rate of bands cemented with AquaCem and subjected to headgear forces compared with the 33% failure rate with Band-Lok when headgear was used. An approximate 2-fold increase in band failure rate has been found when headgear has been applied,[10,11,22] and this finding was confirmed in the present study by a univariate relative hazard of 2.31 for patients treated with headgear vs those treated without.

The effect of the operator on band survival has only been assessed in one other study.[22] Although in that study band failure rates varied greatly from 6% to 30% among operators using a conventional glass ionomer cement,[22] no statistically significant differences were noted among operators in the present study. For univariate analyses, results were pooled across band cement groups, so that although the total number of bands cemented by some operators was small (minimum, 20 bands for operator I), no operator's band total was in single figures. Comparisons between operators are, therefore, still valid statistically. In the study reported here, similarities in clinical practice, with respect to band selection/cementation and treatment mechanics, are likely to account for the absence of any significant operator effect on band survival. However, no attempt was made in this study to look at the interaction between treatment mechanics and operator on band survival. It is likely that there would have been difficulties in achieving convergence of the analysis algorithms had this been attempted because of the modest band data sets available for some operators.

Although an attempt has been made previously to identify predictors of bonded molar tube survival,[4] it appears that a similar assessment has not been made with respect to banded molar teeth. In the present study, headgear use was identified as a predictor of first permanent molar band survival, irrespective of cement type used. When headgear forces are to be applied, it would therefore seem sensible to augment band retention, perhaps by roughening or microetching of the fitting surface. The latter process resulted in an 8-fold reduction in band failure rate compared with untreated bands when Ketac-Cem was used as the luting agent.[29]

This retrospective study analyzed time to first failure of first permanent molar bands cemented with either a modified composite or conventional glass ionomer cement. It therefore has some shortcomings. A randomized split-mouth trial in which bands are allocated randomly to be cemented with either cement would obtain more unbiased data. To date, however, only one clinical trial has been undertaken with similar cements.[27]

The study reported here details the largest comparative analysis of the performance of first molar bands cemented with a modified composite cement, Band-Lok, or a conventional glass ionomer cement, AquaCem. As such, it provides useful information for all clinicians who consider adopting either of these cements for molar band cementation.

## CONCLUSIONS Return to TOC

There was no statistically significant difference in time to first permanent molar band failure for bands cemented with either Band-Lok or AquaCem. Including bands to which headgear was applied, 26% of patients had at least one band failure with Band-Lok, and 30% of patients had at least one band failure with AquaCem, representing an 18% band failure rate for each cement.

Patient sex, patient age at the start of treatment, presenting malocclusion, and operator proficiency did not influence significantly the time to first failure for bands cemented with either Band-Lok or AquaCem, but headgear use significantly reduced the time to first band failure for each cement. Headgear use was identified as a predictor of first permanent molar band survival irrespective of the cement type used.

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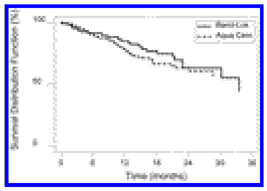
**TABLES** Return to TOC

**TABLE 1.** Sample Characteristics for Bands Cemented with Band-Lok or AquaCem

| | Band-Lok | AquaCem |
|---|---|---|
| No. of bands | 219 | 395 |
| No. of patients | 108 | 183 |
| (men; women) | (53;55) | (82; 101) |
| Median age at start of treatment (y) | 13.1 | 13.1 |
| Lower quartile | 12.2 | 11.9 |
| Upper quartile | 14.2 | 14.2 |
| No. of bands per patient | | |
| 1 band | 4 | 5 |
| 2 bands | 100 | 160 |
| 3 bands | 1 | 2 |
| 4 bands | 3 | 16 |
| Median follow-up time (d) for each patient | 533 | 497 |
| Minimum | 27 | 46 |
| Maximum | 1462 | 1301 |
| No. of patients per malocclusion type | | |
| Class I | 45 | 85 |
| Class II division 1 | 61 | 94 |
| Class II division 2 | 1 | 1 |
| Class III | 1 | 3 |
| No. of patients per treatment mechanics | | |
| No. headgear, palatal arch, lingual arch, and quadhelix | 27 | 33 |
| Headgear | 55 | 54 |
| Headgear and palatal arch | 4 | 24 |
| Palatal arch, lingual arch, and quad-helix | 20 | 67 |
| Information unavailable | 2 | 5 |
| No. of patients per operator | | |
| Operator 1 | 4 | 16 |
| Operator 2 | 7 | 14 |
| Operator 3 | 3 | 33 |
| Operator 4 | 1 | 35 |
| Operator 5 | 28 | 63 |

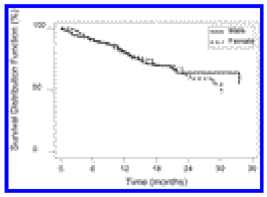
| | | |
|---|---|---|
| Operator 6 | 65 | 22 |

**FIGURES** Return to TOC



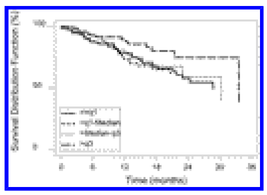
Click on thumbnail for full-sized image.

**FIGURE 1.** Band survival stratified by cement



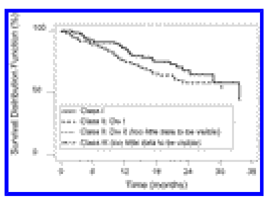
Click on thumbnail for full-sized image.

**FIGURE 2.** Band survival stratified by patient sex



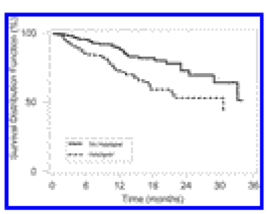
Click on thumbnail for full-sized image.

**FIGURE 3.** Band survival stratified by patient age at the start of treatment



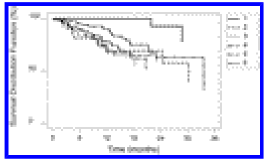
Click on thumbnail for full-sized image.

**FIGURE 4.** Band survival stratified by malocclusion type



Click on thumbnail for full-sized image.

**FIGURE 5.** Band survival stratified by headgear



Click on thumbnail for full-sized image.

**FIGURE 6.** Band survival stratified by operator

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