The practical application of protective stainless steel bands and wedges for prevention of iatrogenic damage during Class II cavity preparations

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Abstract

Objectives: This investigation examined the feasibility of using protective devices for preventing iatrogenic damage to adjacent teeth during Class II cavity preparations. It assessed whether protective devices impair direct vision of the cavity, resulting in unnecessary increase in preparation size; and whether their use prolongs preparation time. **Methods and Materials:** Twenty operators (10 dentists and 10 senior dental students) each prepared Class II cavities on 10 first molar typodont teeth as a baseline, followed by 10 preparations using metal matrix bands as guards on the adjacent teeth, and 10 preparations utilizing interproximal protective wedges with a built in proximal guard strip (FenderWedge®). The time taken was recorded, and the typodonts assessed for the widths and depths of the cavity preparations. **Results:** There was no significant difference in cavity preparation width or depth for operator experience (P=0.261, P=0.952) and use of either guard (P=0.519, P=0.238). Dentists were significantly faster than students in completing cavity preparations both without and with the use of guards. The cavity preparation time was reduced with the use of guards for students, but remained unaffected by use of guards for dentists. **Clinical significance:** Using guards did not result in larger cavities, and they were not seen as a hindrance, particularly by less experienced operators who felt more confident when a guard was in place. As guards can prevent iatrogenic damage during Class II cavity preparations, the benefits of their use outweigh any perceived disadvantages.

Keywords: Iatrogenic damage, prevention, Class II cavity preparation, stainless steel bands, wedges
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Introduction

Various methods exist for preventing iatrogenic damage during preparation of proximal surfaces, although none are in widespread use in clinical practice. Currently available devices that would be suitable as guards include stainless steel matrix bands, interproximal tooth separators with shields such as InterGuard® (Ultradent Products Inc Utah, USA) and interproximal wedges which combine a plastic wedge and a stainless steel plate, such as WedgeGuard® (Triodent Ltd, Katikati, New Zealand), FenderWedge® (Directa AB, Upplands Väsby, Sweden), and Palodent Plus Wedgeguard® (Dentsply Caulk, Delaware USA).

The need for such guards stems from the problem of iatrogenic damage during the preparation of Class II cavities or proximal surface reduction. This issue was first noted in 1972,[1,2] but attracted little interest, perhaps because potentially effective methods for protecting adjacent teeth were available, although rarely used.3 Bur-caused damage to enamel surfaces adjacent to conventional Class II cavity preparations occurs at relatively high rates, with most studies reporting frequencies in the range of 64 - 97%,[3,4,5,6,7] although one study has reported lower rates of 49% - 60%.[8]

When enamel surfaces are damaged the inability of patients to remove the accumulated plaque by flossing from the deepest point of enamel grooves and nicks[5,9] may result in an increased risk of caries. Furthermore, interproximal radiolucencies from iatrogenic damage may be misinterpreted on bitewing radiographs as new carious lesions,[8,10] leading to unnecessary restorative treatment of previously healthy teeth.[6,8]

While the high frequency of damage indicates a need to utilize protective guards as a routine measure, there are no reports of potential disadvantages or risks associated with use of such devices that would explain why they are not utilized in modern dental practice. For instance, some operators may feel that a guard limits their visibility of the Class II cavity being prepared, which could slow the progress of their work or lead to a larger cavity being prepared. Such considerations, if confirmed, would render these devices unusable in clinical practice. This study therefore examined whether the use of interdental guards inserted to protect the adjacent teeth from inadvertent damage alters the dimensions of the Class II cavities being prepared (specifically, whether a larger than necessary cavity is prepared), and whether the presence of a guard prolongs the time needed to complete the cavity preparation. The impact of operator experience as a variable was also considered, by involving both dental students and experienced dentists as operators. The study compared the effects of using as guards either standard metal matrix bands or FenderWedges™ during Class II cavity preparation. The findings would likely also be relevant to the scenario of full crown preparation, where an even higher frequency of enamel damage reportedly occurs.[11,12]

Methods and materials

This study was part of a series of investigations into iatrogenic damage to adjacent teeth during Class II cavity preparations. A total of 10 final year dental students and 10 experienced general dentists served as operators. All operators worked under simulated clinical conditions, on identical phantom heads, with standardized equipment and lighting. A full, unrestored dentition was present in all typodont sets of teeth. Because all operators had been trained on Frasaco teeth (Frasaco gmBH, Tettnang, Germany) at the University of Queensland School of Dentistry during their studies, typodont teeth from this same supplier were used for continuity. The teeth were prepared using air turbine handpieces (Pana-Max PAX-TU M4, NSK, Tochigi, Japan) with medium-grit cylindrical diamond high-speed burs (Horico Diamant FG108010, Horico, Berlin, Germany). A standardized cavity preparation method for Class II cavity preparations (MO and DO designs) was utilized.

Each operator initially prepared 10 MO and 10 DO Class II cavity preparations in typodont first molars without the use of any guards, followed by a further set of preparations utilizing FenderWedges® (Directa AB, Upplands Väsby, Sweden) placed interdentally, and finally a series of preparations utilizing standard stainless steel matrix bands placed interdentally. The largest size of FenderWedge (yellow wedges) was used, to create a worst-case scenario in terms of obstruction of visual access. The participants were instructed to follow their normal technique and not to prolong their preparation time in order to minimize the extent of iatrogenic damage. The time taken for each operator to prepare the cavities was recorded using a digital stopwatch. At the end of the phantom head work, the operators were surveyed regarding their experiences of the various protective devices.

The maximum proximal box width and depth of the 20 cavity preparations prepared by each operator under the three situations was measured firstly with digital calipers (model 799A-6/150 Digital Vernier Calipers, LS Starrett Inc, Athol, MA, USA), with cavity width and depth measured to the nearest 0.01 mm. The typodont teeth were then digitized (CEREC Blu-Cam scanner, Sirona Dental Systems, GmbH, Bensheim, Germany) and the dimensions of the cavities measured with PrepCheck® software from the same supplier. The stated accuracy of the digital scans was 0.019 mm, and all readings from the digital scans and the digital calipers were in agreement within 0.05 mm. A typical image from the digitized teeth is shown in Figure 1.

Statistical analysis

The data sets for time taken for cavity preparation were analyzed using JMP® software version 10 (SAS Institute Inc, Cary, NC, USA) with a repeated measures analysis of

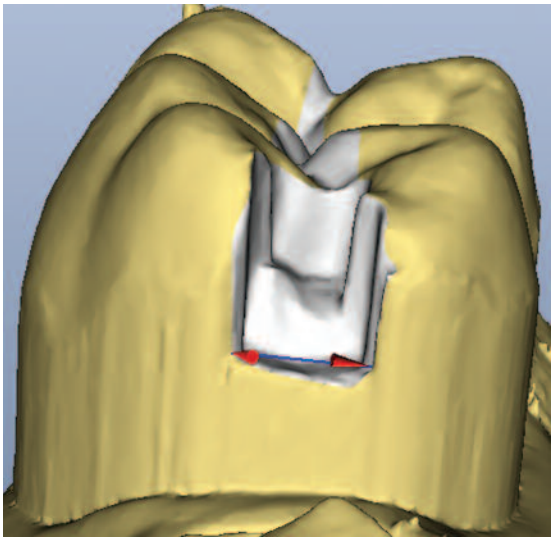

Figure 1: Class II preparation imaged using the Sirona CEREC Blu-Cam system showing cavity width measurement for the proximal box.

Table 1: Relationships between cavity preparation times for operators and guard use

	Time, no guard			Time, stainless steel matrix band			Time, protective wedge		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Experienced Dentists	7.0	4.1	10	6.8	4.0	9.25	6.9	4.2	9.0
Student	12.8	10.2	15.0	11.6	9.25	13.75	11.3	9.7	13.5

Mean, minimum and maximum cavity preparation times in minutes for experienced dentists and final year dental students for cavity preparations without a guard, with a stainless steel band, and with a protective wedge.

variance The data was validated with Mauchly's sphericity test, to ensure that the variances of the differences between all possible pairs of groups (i.e., levels of the independent variables) were equal, which is an important assumption of a repeated measures ANOVA.

The data for changes to cavity preparation widths and depths was analyzed in SPSS® software version 22 (IBM, Armonk, NY, USA). A linear mixed model was fitted to compare the primary outcomes of depth and width of the cavity for students and experienced dentists. The fixed effects in the model were group (experienced dentists and students), device (none, wedge, stainless steel band), group-device interaction and a repetition variable to determine if there was a difference in cavity depth between the first and second preparation.

Correlation between the repeated measures for the devices by preparation repetition combination was modeled using the residual covariance matrix with a compound symmetry structure. While two structures were tested to find the best covariance structure, the compound symmetry structure gave the best results.

Results

The gender ratio of the participating operators was 45% female and 55% male. All senior dental students were aged in their early twenties. The age of the dentists was not recorded, however they all had at least 5 years of clinical experience.

Preparation time

A repeated measures ANOVA was fitted to the data for times for cavity preparations for experienced dentists and students with and without guards. The sphericity test result was significant (P = 0.000051), indicating a difference in the variance between no guard and the use of a stainless steel band or a wedge. Accordingly, the multivariate F test and the adjusted univariate F test were then used. The reason for the adjustment is that when the sphericity pattern is not present, the F test may lead to inappropriate rejection of the null hypothesis. Correction of the degrees of freedom using the Greenhouse and Geisser epsilon factor was therefore considered. The univariate G-G and H-F tests were both significant (P=0.0041 and P=0.0031), indicating a difference in time for cavity preparations between dentists and students. There was no difference in time required for experienced dentists to prepare teeth with or without the use of guards, however for students the time needed for cavity preparation reduced when guards were used.

Table 1 presents the least squares mean time for students and experienced dentists to complete one preparation without a guard, with a wedge and with a stainless steel band. The overall preparation time for students was reduced by approximately 1 minute from an average of 12.8 minutes drilling without a guard, to 11.6 minutes and 11.3 minutes with a stainless steel band and with a FenderWedge, respectively.

Preparation width

Examination of preparation widths determined values for the Corrected Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) of 290.96 and 299.14 respectively. There was no significant difference between experienced dentists and students in cavity preparation widths (P = 0.261), no significant effect for devices (no protection, use of stainless steel band, wedge, P=0.544), and no interaction between the two variables (P = 0.534). There was no significant impact of the repetition of preparation (P = 0.093).

As shown in Table 2, there were no significant differences in marginal mean widths for both students and dentists when drilling without a guard, with a stainless steel band and with a protective wedge.

Table 2: Cavity preparation widths

	Mean widths, no guard			Mean widths, stainless steel matrix band			Mean widths, protective wedge		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Experienced Dentists	3.3	1.5	5.3	3.0	1.9	5.1	3.3	2.6	5.3
Student	3.4	2.3	4.6	3.5	1.8	4.2	3.5	1.9	4.5

Mean widths (in mm) for students and dentists when drilling without a guard, with a stainless steel band and with a protective wedge.

Preparation depth

As was found for preparation width, the protective devices did not cause an increase in cavity depth. Examination of the depth of the preparation determined values for AIC and BIC of 134.92 and 143.10, respectively. No significant differences were found between experienced dentists and students in cavity preparation depths (P = 0.952), no significant difference between the various devices (P = 0.238), and no interaction between the two (P = 0.138). There was no significant impact of the repetition of preparation (P = 0.726). As shown in Table 3, there were no significant differences between mean depths for use or not of the protective devices (no guard, use of a stainless steel band and use of a wedge) for both students and experienced dentists.

Some 30% of all operators felt that the bands and to a lesser extent the FenderWedges partially obscured their vision, however only 10% of experienced dentists believed they worked slower with these devices in place. Some 90% of students believed that they worked faster when protective devices were present, while 10% noted no difference in their speed of work. Some 95% of operators believed that using protective devices reduced the extent of iatrogenic damage caused.

The feedback survey revealed that students believed they worked faster and with greater confidence when guards were present. One student even noted that: '…added protection from iatrogenic damage resulted in reduced [operator] stress while working.' When surveyed on their experience with the use of the two different protective devices, dentists gave a mixed response. One dentist reported being 'unused to the presence of a protective device between the teeth, and so probably worked slower than usual initially.' Others noted that they worked faster as they could take slightly less care (within reason) regarding damaging the adjacent tooth with the protective devices in place. Only one dentist felt that they consistently worked less efficiently when protective devices were present. Three dentists stated that the stainless steel band, and to a lesser extent the smaller stainless steel plate on the FenderWedge partially obscured their vision of the cavity preparation.

Discussion

Despite past studies suggesting there would be benefits from using protective devices to prevent iatrogenic damage during conventional Class II cavity and crown preparations,[5,8,11,12] these devices are not used commonly in clinical practice. The expected benefits need to be balanced against potential

Table 3: Cavity preparation depths

	Mean depths, no guard			Mean depths, stainless steel matrix band			Mean depths, protective wedge		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Experienced Dentists	2.9	2.3	3.4	2.7	2.4	3.5	2.9	2.3	3.7
Student	2.9	1.5	3.9	2.9	1.8	3.5	2.8	2.2	4.0

Mean depths of cavities (in mm) for students and dentists when drilling without a guard, with a stainless steel band and with a protective wedge.

adverse effects. As caries removal is aided by visual inspection as well as tactile examination methods, there is a potential risk that the obstruction of direct vision could result in an increase in size of and time for cavity preparations.[14] The present study did not find a statistically significant change in the width and depth of Class II cavity preparations made by either experienced dentists or senior dental students when protective devices were utilized. The final preparations were of comparable size between the two groups of operators (as shown in Table 1).

The average times taken by dentists and students in the current study to complete a single cavity preparation without guards (7 and 12.8 minutes respectively) are somewhat shorter than those reported in a comparable study by Lussi et al. (14.9 minutes). The participants of the present study were specifically instructed not to prolong their preparation procedures, but rather to replicate as closely as possible their normal clinical working procedures. This could explain the difference in time taken for cavity preparations between the two investigations.

An unexpected result in the current study was that students when using protective devices reduced the average time for cavity preparation by approximately 1 minute or some 8%. This small impact on productivity is unlikely to be noticeable on a single cavity preparation procedure, as students on average took 63-82% longer than experienced dentists to complete cavity preparations of comparable quality with and without guards. However, students subjectively felt more confident when utilizing guards during their work. One would not expect the level of confidence to be a factor with experienced dentists, and unsurprisingly, using protective devices did not affect the productivity of the dentists. Despite being unaccustomed to their use, only 1 of the 10 dentists subjectively perceived his/her efficiency to be hindered by the use of a guard.

Conclusions

Using either a stainless steel matrix band or a FenderWedge did not result in a statistically significant change to cavity preparation width and depth for Class II cavity preparation in molar teeth, nor did it impair productivity. Rather, using a guard gave a small boost (in the order of 8%) to the productivity of less experienced operators, because of greater confidence. Therefore, the benefits of using such protective devices to prevention iatrogenic damage outweigh the commonly perceived risks and disadvantages. Due to the high reported rates of iatrogenic damage[3,4,5,6,11,12] and its potential adverse consequences, there is a sound rationale in using protective devices when preparing proximal surfaces of posterior teeth.

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