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Influence of the Rubber Dam on Proximal Contact Strengths

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Clinical Relevance

The use of a rubber dam results in major effects on proximal contact strengths during treatment, which the dentist should be aware of in order to avoid negative effects on the quality of the restoration.

SUMMARY

Purpose: The study tested the hypothesis that the application of a rubber dam influences the reconstruction of proximal contact strengths, while the corresponding contra-lateral teeth are not affected.

Methods: Seventy-four systemically and periodontally healthy subjects in need of a direct posterior composite restoration were treated with the use of a rubber dam. The proximal contact strengths (PCS) were electronically evaluated by measuring frictional forces during removal of a 50.0 ± 5.0 µm-thick straight metal band.

Results: Proximal contact strengths significantly increased from 2.26 ± 1.45N before to 3.83 ± 2.34N after application of the rubber dam; whereas, the variation of PCS at the corresponding contacts in the contra-lateral quadrant remained within the intra-examiner variance of ± 0.2N. Upon removal of the rubber dam, there was a statistically significantly drop in PCS from 3.54 ± 1.87N to 2.31 ± 1.35N. Again, there was only minimal change in the contra-lateral quadrant. It was concluded that application of the rubber dam affects proximal contact strengths.

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INTRODUCTION

Directly inserted composites are used more and more for the reconstruction of Class II cavities and proximal contacts (PC). PC plays an important role in the stomatognathic system, stabilizing the dental arch during mastication and protecting the periodontium from food impaction. Rebuilding a very strong PC might work like an orthodontic appliance; whereas, a weak PC would lead to food impaction in the periodontal gap.

Thus, it is necessary to reconstruct the PC with adequate proximal contact strengths (PCS). In order to achieve the best results working with composites, the use of a rubber dam is recommended. Not only is it even easier to keep the surface dry, but the overview is also enlarged, and the aerosol is not contaminated with the bacterial flora of the patient's mouth, resulting in less risk of infection (Cochran & others, 1989; Marshall, 1998).

Earlier studies have shown significant changes in PCS during treatment with a rubber dam, but, to date, none were done with the contra-lateral PCS as control. In order to know whether the changes in PCS between the dried teeth result from the use of a rubber dam, it is actually necessary to observe the changes within the contra-lateral quadrant. Many different factors exist that influence the PCS, such as the time of day, chewing activity, positioning during measurement and the degree of mouth opening (Dörfer & others, 2000). It is not yet clear whether the effects shown with former studies are caused by application of the rubber dam only or whether they are the results of other PCS-influencing factors that might occur during the treatment procedure.

This study 1) investigated the changes in PCS due to the use of a rubber dam within the application area; and 2) measured PCS in the contra-lateral quadrant by excluding the effects of other influencing factors besides the application of a rubber dam.

METHODS AND MATERIALS

The study was performed on 74 consecutive presenting patients, 41 females and 33 males with no history of periodontal treatment, using pocket probing depths of 4 mm or less. The patients had an average age of 37 ± 13 years. All patients signed an informed consent form and were in need of a direct posterior composite restoration, which was placed under a rubber dam (Hygenic Corporation, Akron, OH, USA). The restoration could include either one, both or no proximal contact. The rubber dam was placed over the entire quadrant in which the treatment was performed, and the holes were punched in a standardized manner using a standardized marking device (KKD Topdent GmbH, D-73479 Ellwangen, Germany). A molar rubber dam clamp was placed on the most posterior tooth, which, in 66 cases, was the second molar, and in eight cases, was the first molar. All restorations were made with a dentin-adhesive system (Optibond FL, Kerr Corporation, Orange, CA, USA) and a hybrid-composite material (Herculite, Kerr Corporation) using an oblique-layering technique. The PCS were measured at both contacts next to the restoration (mesial contact, M, and distal contact, D), with one additional contact in either the mesial or distal direction (additional contact). The corresponding sites in the contra-lateral quadrant were measured as well.

Measurements were taken five times during treatment. First, at the baseline just before application of the rubber dam, then immediately after placement. The next two measurements were taken just before and after removal of the rubber dam. An additional measurement was taken upon completion of the session, when the treatment was finished.

PCS was quantified indirectly by the creation of interproximal forces during removal of a 0.05-mm thick metal strip (Meba, Balingen, Germany) which was inserted between two adjacent teeth. While use of this metal strip interproximally displaced the periodontal tissue, it exerted a force against and perpendicular to the strip at the proximal contact. To standardize time-dependent displacement of the teeth due to the properties of the periodontal ligament, the strip was removed immediately after insertion. The friction induced by the perpendicular force was measured while removing the strip from the proximal areas. PCS was quantified as the maximum frictional force. The method first described by Osborn was modified, so that the strip was removed in an occlusal direction rather than a buccolingual direction, allowing for better access to the posterior teeth (Southard, Behrents & Tolley, 1990a; Osborn 1961).

The strip was fixed to a special holder, equipped with strain gauges (N3K-06-S022H-50C, Measurements Group Inc, Raleigh, NC, USA) to measure the forces necessary to remove the strip relative to the teeth. One set of strain gauges was located on the shank of the holder, forming a complete Wheatstone bridge. These strain gauges registered the bending action of the holder during removal of the strip from the proximal contact area (Figure 1). This force measurement component was calibrated every morning prior to taking measurements by using accurate weights. The movement of the strip relative to the teeth was measured with a metal pin that moved through a guide parallel to the movement to the strip and was seated on the occlusal or

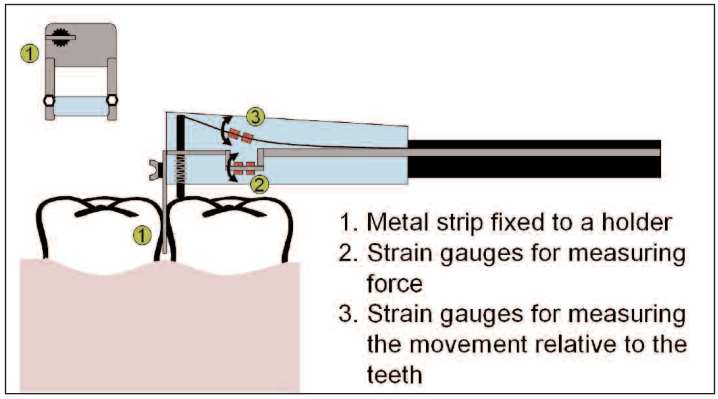

Figure 1. *Holder with the matrix band inserted between two teeth (1). The forces are registered at (2). The movement of the matrix band relative to the tooth is registered at (3).*

incisal aspect of the mesial partner of the two teeth that formed the proximal contact to be measured. A second set of strain gauges registered movement of the pin relative to the holder and, therefore, movement of the holder relative to the teeth, again forming a complete Wheatstone Bridge. The movement measurement component was calibrated every morning prior to the measurements using a 10.0 ± 0.1 mm metal step. The forces and movement were registered at a frequency of 2000Hz. Customized software (PD T Pioch, Clinic for Conservative Dentistry, Heidelberg, Germany) was used for force data analysis and to construct diagrams ("wayforce") relating the force [N] to the position [mm]. Visible irregularities of the graph, for example, due to deformations of the metal strip during positioning, precluded the inclusion of the data for analysis and led to a repetition of the experiment. All measurements were taken by the primary investigator, with the patient sitting in a dental unit. The angulation of the unit was not changed during treatment (Southard & others, 1990a).

Mean values and standard deviations of the PCS in both groups were calculated. The differences before and after application and removal of the rubber dam were tested for statistical significance with the paired *t*-test. Where two subgroups were present (mandible/maxilla), the differences in PCS were compared and tested for statistical significance by the *t*-test for independent variables. Possible final significant differences were calculated with the post hoc Bonferoni procedure. The significance level was set at $p<0.05$. Statistical analysis was performed using the statistical software package SPSS (SPSS 11.0, Chicago, IL, USA).

RESULTS

All 74 subjects completed the study procedure. A total of 17 mesial-occlusal, 18 mesial-occlusal-distal, 26 occlusal-distal and 13 occlusal fillings were placed. The overall proximal contact strengths for maxilla and mandible within the area of rubber dam application rose from 2.27 ± 1.23N at baseline to 3.80 ± 2.30N immediately after application of the rubber dam. This difference was statistically significant ($p<0.05$) and is related to a relative increase of 69.6% of the mean value. The PCS of the corresponding sites in the contralateral quadrant changed from 2.44 ± 1.23N to 2.58 ± 1.28N (Table 1). Comparing the PCS before removal of the rubber dam and immediately after showed a relative decrease of -34.2%. It dropped from 3.37 ± 1.54N to 2.18 ± 1.09N ($p<0.05$), whereas, the control side remained almost unchanged (2.42 ± 1.76N to 2.31 ± 1.13N). Within an average of 20 minutes after removal of the rubber dam and completion of the treatment, the overall PCS further dropped to 1.96 ± 1.22N on the test and dropped to 2.29 ± 1.23N on the control side.

In total, the treatment lasted an average of 112 ± 15 minutes, with the rubber dam in place for 80 ± 13 minutes.

Compared to the maxilla, the mandible showed greater changes (Table 2). The application of the rubber dam was followed by an increase from 2.41 ± 1.52N to 4.29 ± 2.55N ($p<0.05$) in PCS in the mandible at M. This corresponds to a relative increase of 78.0%. In the maxilla, the PCS at baseline at M was 2.09 ± 1.36N and, after application of the rubber dam, it was 3.28 ± 1.98N (57.0%; $p<0.05$). Upon removal, the PCS dropped in the mandible from 4.03 ± 2.08N to 2.53 ± 1.49N (-37.2%; $p<0.05$). In the maxilla, it changed from 2.96 ±

Table 1: *Proximal contact strength (PCS) before and immediately after rubber dam-application, and before and immediately after rubber dam removal as the average of maxillary and mandibular values. Mean value ± standard deviation are listed as well as the statistical significance for differences before and after rubber dam-application/removal by paired* t*-test.*

		Treated Quadrant				Control Quadrant		
Contact		Mesial Contact M	Distal Contact D	Additional Contact	All Three Contacts	Corresponding to M	Corresponding to D	Both Contacts
PCS [N] (before rubber dam-application)		2.26 ± 1.45	2.27 ± 1.43	2.19 ± 1.52	2.27 ± 1.23	2.46 ± 1.20	2.41 ± 1.55	2.44 ± 1.23
PCS [N] (after rubber dam-application)		3.83 ± 2.34	3.83 ± 2.37	3.76 ± 2.19	3.82 ± 1.96	2.61 ± 1.21	2.56 ± 1.60	2.58 ± 1.28
Paired *t*-test	P	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
PCS [N] (before rubber dam-removal)		3.54 ± 1.87	3.14 ± 1.83	3.25 ± 1.93	3.37 ± 1.54	2.44 ± 1.07	2.41 ± 1.53	2.42 ± 1.76
PCS [N] (after rubber dam-removal)		2.31 ± 1.35	1.99 ± 1.21	2.23 ± 1.50	2.18 ± 1.09	2.29 ± 1.01	2.34 ± 1.49	2.31 ± 1.13
Paired *t*-test	P	<0.001	<0.001	<0.001	<0.001	<0.001	0.175	<0.001

Table 2: *Proximal contact strength (PCS) before and immediately after rubber dam application and before and immediately after rubber dam removal. Mean value ± standard deviation are listed as well as the statistical significance for differences before and after rubber dam application/removal.*

		Treated Quadrant			Control Quadrant	
Maxilla Contact		Mesial Contact M	Distal Contact D	Additional Contact	Corresponding to M	Corresponding to D
PCS [N] (before rubber dam application)		2.09 ± 1.36	1.89 ± 1.44	1.63 ± 1.56	2.12 ± 0.79	2.21 ± 1.57
PCS [N] (after rubber dam-application)		3.28 ± 1.98	3.00 ± 1.98	2.78 ± 1.75	2.26 ± 0.81	2.36 ± 1.67
Paired *t*-test	P	<0.001	<0.001	<0.001	0.025	0.002
PCS [N] (before rubber dam-removal)		2.96 ± 1.42	2.64 ± 1.60	2.37 ± 1.40	2.12 ± 0.77	2.25 ± 1.63
PCS [N] (after rubber dam-removal)		2.05 ± 1.12	1.84 ± 1.22	1.64 ± 1.02	2.06 ± 0.80	2.25 ± 1.61
Paired *t*-test	P	<0.001	<0.001	<0.001	0.190	0.936
Mandibula						
PCS [N] (before rubber dam-application)		2.41 ± 1.52	2.60 ± 1.35	2.78 ± 1.67	2.75 ± 1.41	2.59 ± 1.53
PCS [N] (after rubber dam-application)		4.29 ± 2.55	4.54 ± 2.26	4.80 ± 2.18	2.91 ± 1.41	2.73 ± 1.54
Paired *t*-test	P	<0.001	<0.001	<0.001	0.022	<0.001
PCS [N] (before rubber dam-removal)		4.03 ± 2.08	3.57 ± 1.92	4.18 ± 2.00	2.71 ± 1.22	2.54 ± 1.45
PCS [N] (after rubber dam-removal)		2.53 ± 1.49	2.12 ± 1.20	2.87 ± 1.69	2.48 ± 1.14	2.42 ± 1.40
Paired *t*-test	P	<0.001	<0.001	0.003	<0.001	<0.001

1.42N to 2.05 ± 1.12N (-30.1%; $p<0.05$). The PCS in the control quadrants in the maxilla showed no statistically significant changes.

DISCUSSION

In recent years, direct tooth colored restorations have become more popular for larger Class II cavities. As material characteristics have improved and the problems of wear seem to be solved, the handling of composite has to be examined, such as keeping the conditioned surface clean of saliva and blood and reconstructing an adequate proximal contact. The use of a rubber dam is one of the most recommended techniques for achieving these goals. In addition, a rubber dam offers many benefits to the operator and patient, as it acts as a barrier. Most patients are more relaxed, as they feel protected against swallowing or aspiration of substances, and the operator is protected against infective aerosols. Additionally, in most cases, access to the cavity is easier, and the risk of bleeding due to traumatization of the interdental papillae is reduced. However, there is some clinical evidence that use of a rubber dam makes the reconstruction of adequate proximal contacts more difficult. Testing the reconstructed proximal contact under rubber dam with dental floss was usually positive; whereas, after removing the rubber dam, the contact was sometimes gone. Therefore, in order to achieve the best results, it is necessary to know how the rubber dam influences proximal contact strengths. Additionally, previous studies have already reported the effects of a rubber dam on proximal contacts (Dörfer & others, 2001), but, so far, they could not exclude any other influences. To make sure the other factors influencing the PCS, for example, reclining in the dental chair for a certain amount of time or keeping the mouth open during the entire treatment (Southard & others, 1990b) could be distinguished, the authors measured the PCS not only in the area where the rubber dam was placed, but also as a control in the contra-lateral quadrant, where no rubber dam was placed.

The results showed significant inter-individual variances, which are in accordance with the literature (Dörfer & others, 2001; Osborn, 1961; Southard & others, 1990b). Nevertheless, the changes in PCS in one patient, which occurred at the site where the rubber dam was placed, were statistically significant regardless of the initial strengths of the contacts. The reverse effect could be seen when removing the rubber dam. These changes were not seen at the contra-lateral control sites, indicating that, indeed, the changes have to

be regarded as a negative side effect of rubber dam application. Due to the study design used, other treatment related effects, such as the patient almost being placed in a horizontal position and being forced to open one's mouth widely for an extended period of time can be excluded, as they should have affected the contralateral control sites as well.

So far, the mechanisms leading to these effects are not well documented. One reason could be that the holes in the rubber dam were punched in a standardized manner and not individually for each subject. In case the distance between the holes was shorter than the distance between the teeth, the rubber dam would have had to be stretched to fit. Doing so would result in a pulling-force directed to the middle of the dried area. Also, the stretched rubber dam could induce a mesial force vector by pushing the clamp up and mesially. Another reason might be the thickness of the rubber dam itself. Once placed, the rubber dam can act like a separation device (Dörfer & others, 2001). These effects could result in a slight rotation of the adjacent teeth into the cavity when the proximal contact is removed during cavity preparation, therefore, narrowing the space for the restoration. These effects appeared to be more pronounced in the mandible compared to the maxilla, which might be due to the difference in bone structure.

CONCLUSIONS

Although the results indicate that use of a rubber dam increases the risk of outcome of weaker proximal contacts after reconstruction with directly inserted composite, there is still no doubt that the use of a rubber dam is of great benefit for the entire treatment procedure. However, the direct reconstruction of proximal contacts with composites in posterior teeth is still a challenge to the operator. It might be helpful, therefore, to understand the role of the rubber dam in this entity of factors that influence treatment outcome, and additional efforts should be undertaken to compensate for its influence. These measures could include multiple wedging techniques, where the operator positions the wedges just after application of the rubber dam to give the wedges time to separate the teeth, as well as the use of additional special separation rings. Other options could include extending the area under the rubber dam as much as possible in order to distribute the forces onto as many roots as possible or to adopt the distances between the punched holes to the individual tooth size and position. However, further studies have to be undertaken to investigate which of these techniques will best reduce the negative effects of the rubber dam.

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