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Evaluation of Proximal Contact Tightness of Class II Resin Composite Restorations

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Clinical Relevance

The use of sectional matrix bands combined with a separation ring and wedge is recommended to reconstruct the proximal contact area of Class II resin composite restorations.

SUMMARY

Objective: The objective of the current study was to compare *in-vitro* the proximal contact tightness (PCT) of Class II resin composite restorations (RCR) placed with different established and new placement techniques. Methods: 105 ivorine lower left first molars with standardized MO cavities were randomly divided into seven groups (n=15) as follows: SRing: sectional matrix and separation ring (Garrison Dental); CRing: circumferential matrix (1101-c, KerrHawe SA) with separation ring; CWedge: circumferential matrix with a wedge only; COptra: circumferential matrix and OptraContact (Vivadent); CCerana: circumferential matrix and a Cerana insert (Nordiska Dental); CElliot: circumferential matrix and Elliot separator (PFINGST & Co) and Walser: Walser matrix O-type (Dr Walser Dental GmbH). In all the groups, the matrix band was secured using a wooden wedge except for the Walser group, following manufacturer's recommendations. A Tofflemire retainer (Kerr Corporation) was used to apply the circumferential matrix band whenever it was used. All the prepared teeth were restored with resin compos-

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ite (Premise, Kerr) mounted in a manikin head to simulate the clinical environment. PCT was measured using the Tooth Pressure Meter (University of Technology, Delft). The data were analyzed using one-way ANOVA and Tukey post-hoc tests (p<0.05). Results: Compared to the control group (SRing) (6.64 ± 1.06N), all other systems resulted in significantly lower PCT values (p<0.001). Within the circumferential matrix groups, CRing (4.01 ± 0.53N) and CElliot (4.29 ± 1.08N) showed significantly tighter contacts compared to the CWedge (0.37 ± 0.22N), COptra (0.91 ± 0.49N), CCerana (2.99 ± 1.98N) and Walser (1.34 ± 0.55N) (p<0.05) group. Between CWedge and COptra, no significant difference was found (p=0.57). Conclusion: The use of separation rings with sectional matrices provides superior contacts when placing Class II RCRs.

INTRODUCTION

One of the greatest challenges encountered by even the most experienced clinicians when placing Class II resin composite restorations is creating tight proximal contacts and obtaining anatomically correct proximal contours. One must understand the role of a proximal contact in the natural dentition to better appreciate the importance of reproducing its shape and tightness during tooth restoration. Proximal contact tightness (PCT) is a physiological dynamic entity of multifactorial origin that is greatly affected by tooth type, location, time of day, patient position, mastication and restorative procedures.[1-2] A significant variation in proximal contact was also observed both inter- and intra-individually.[1,3]

The role of the proximal contact in protecting the periodontium against damage due to food impaction is very important.[1,4] It is well known that loose proximal contacts predispose to food impaction, tooth migration, periodontal complications and carious lesions.[4-7] On the other hand, trauma to gingival tissue has been observed when excessive pressure has to be applied to pass dental floss through contacts that are too tight.[5,8-10]

The difficulty in obtaining a tight proximal contact with resin composite has been attributed to the inherent polymerization shrinkage and lack of condensability of resin composite materials,[11-12] the use of a rubber dam[13-14] and the thickness and elastic displacement of the matrix band.[3,15] In an attempt to provide tighter, more anatomic proximal contacts, several techniques and instruments have been proposed.[6,11,16-17] One technique described was the application of heavy wedging, which failed to provide a tight proximal contact.[18] Special hand-instruments with convex prongs that apply lateral force at the contact area during curing have shown limited success.[18-19] Several studies unsubstantiated claims that high viscosity resin composite produces tighter proximal contacts.[12,19-21] When the effect of matrix band type on proximal contacts was investigated, the performance of transparent bands was found to be comparable to that of metal bands.[22-23] Pre-contoured matrix bands demonstrated superior contours when compared to flat matrix bands.[21,24] The use of pre-contoured circumferential or sectional matrix bands combined with a separation ring has been shown to achieve good contact tightness due to the interdental separation the ring applies during restoration.[3,12,19,25-27] The use of prefabricated ceramic inlays was also recommended in an effort to minimize the effect of polymerization shrinkage.[28] When combined with resin composite, ceramic inserts have been shown to provide acceptable contact tightness.[18,27,29] The general conclusion from all these studies is that the key factor to producing a tight proximal contact is obtaining interdental separation during placement of the restoration.

Currently, new techniques are continuously being introduced, with no solid scientific evidence to support their claims. Therefore, the current study investigated several new techniques to restore two-surface Class II resin composite restorations and compare them to the proven "gold standard."

The hypothesis (H_0) to be tested in the current study was that the use of new systems would lead to equivalent contact tightness when restoring two-surface Class II resin composite restorations compared to the use of a sectional matrix system combined with separation rings ("gold standard").

METHODS AND MATERIALS

The contact area between an ivorine lower left second premolar and first molar (Kilgore International, Coldwater, MI, USA) was selected for this experiment. An occluso-mesial (MO) cavity was prepared in an ivorine lower left first molar. The dimensions of the proximal portion were 5.0 x 4.0 x 2.0 mm buccolingual, occlusogingival and mesiodistal, respectively. The dimensions of the occlusal portion were 4.0 x 2.5 x 3.0 mm buccolingual, occlusopulpal and mesiodistal, respectively. In order to standardize the cavity design and dimensions throughout the study, the prepared tooth was sent to the manufacturer for duplication to produce 105 replicas. All cavity restorations were performed on a manikin model (Kilgore International) mounted in a manikin head (Kavo Dental, Biberach, Germany) to simulate clinical conditions. The lower left second premolar was replaced with a copper-zinc alloy cast replica to prevent wear of the distal tooth surface during cavity restoration and contact tightness measurement (Figure 1). The teeth were equally divided into seven groups (n=15) as follows:

Group 1 (SRing): A 5.5 mm sectional Molar Matrix (Composi-Tight Silver Plus, Garrison Dental Solutions, Spring Lake, MI, USA) was secured with a wedge

Figure 1: *Prepared cavity in the lower left first molar and cast premolar used for all test groups in the current study.*

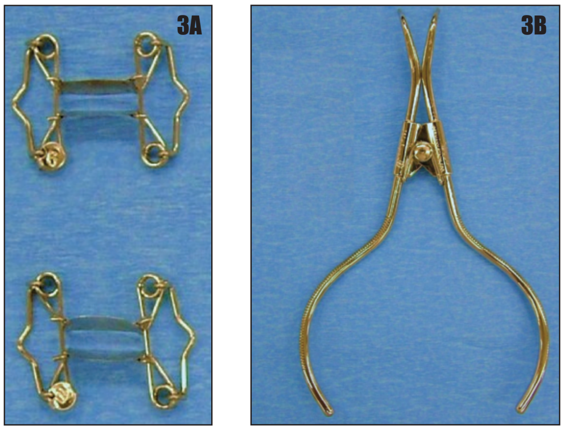

Figure 3A: *Walser matrix (O-form #10) and Figure 3B matrix forceps.*

(Sycamore Wedges, Premier Dental Products Co, Plymouth Meeting, PA, USA) and combined with a separation ring (Composi-Tight Silver Plus).

Group 2 (CRing): A circumferential matrix 1101-c (KerrHawe SA, Bioggio, Switzerland) in a Tofflemire retainer (Kerr Corporation, Orange, CA, USA) was secured with a wedge and combined with a separation ring (Composi-Tight Silver Plus).

Group 3 (CWedge): A circumferential matrix 1101-c in a Tofflemire retainer was secured with a wedge. No additional interdental separation was used.

Group 4 (COptra): A circumferential matrix 1101-c in a Tofflemire retainer was secured with a wedge and, during polymerization of the first layer of resin composite, a hand-instrument (OptraContact, Ivoclar Vivadent, Schaan, Liechtenstein) was placed against the contact area to press the matrix band against the adjacent tooth.

Group 5 (CCerana): A circumferential matrix 1101-c in a Tofflemire retainer was secured with a wedge. A

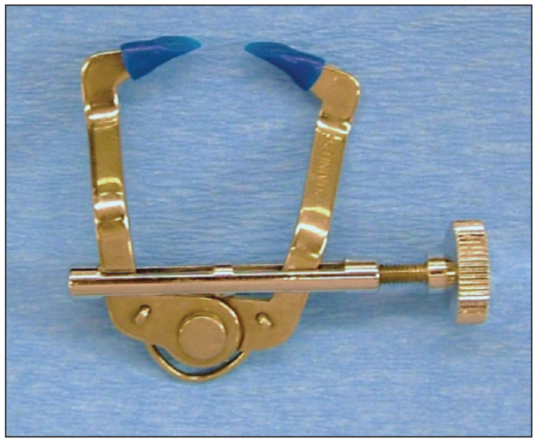

Figure 2: *Elliot separator with modified beaks.*

Medium Class II ceramic insert (Cerana, Nordiska Dental, Ängelholm, Sweden) was pressed into the resin composite and kept under pressure during polymerization.

Group 6 (CElliot): A circumferential matrix 1101-c in a Tofflemire retainer was secured with a wedge after which an Elliot separator (Pfingst & Co, South Plainfield, NJ, USA) was applied. The beaks of the device were slightly modified using rubber tips (OptraSculpt, Ivoclar Vivadent) as shown in Figure 2.

Group 7 (Walser): An O-form #10 Walser matrix (Dr Walser Dental GmbH, Radolfzell, Germany) was placed. No wedge or additional separation was used in combination with this system as per manufacturer recommendations (Figure 3).

Prior to the adhesive procedures, the contact area in the matrix band was carefully burnished with a hand-instrument (PFI 49, Dentsply Ash, Weybridge, Surrey, United Kingdom) so that no visual space was left between the matrix and the adjacent tooth. The adaptation of the matrix band at the gingival cavity margin was checked with an explorer. The adhesive (OptiBond All-in-One, Kerr Corporation) was applied according to the manufacturer's instructions and polymerized with a halogen polymerization unit for 10 seconds (QHL75 lite, Dentsply, York, PA, USA, light intensity 450 mW/cm^2). Resin composite (Premise, Kerr Corporation) was then applied in three increments: a horizontal gingival, an oblique buccal and an oblique lingual increment. Each layer was separately cured for 20 seconds from the occlusal direction. All the restorations were placed by one operator. This protocol was modified for the COptra and CCerana groups. In the COptra group, the OptraContact hand-instrument was placed into the gingival increment and mesial pressure was applied during polymerization. In the CCerana group, the cavity was filled with resin composite. The insert was then submerged into the uncured resin composite and gross excess was removed. The entire restoration was cured

Table 1: *Test Group, Matrix System, Presence of Retainer, Wedge Availability and Position, and Type of Separation Method*

Test Group	**Matrix System**	**Retainer**	**Metal Matrix Characteristics and Thickness**	**Wedge**	**Separation Method**
SRing	Composi-Tight Silver Plus 5.5 mm molar band	None	Dead-soft sectional 0.033 mm	yes lingual	Separation ring
CRing	1101c	Tofflemire	Flexible circumferential 0.035 mm	yes lingual	Separation ring
CWedge	1101c	Tofflemire	Flexible circumferential 0.035 mm	yes lingual	None
COptra	1101c	Tofflemire	Flexible circumferential 0.035 mm	yes lingual	Contact instrument
CCerana	1101c	Tofflemire	Flexible circumferential 0.035 mm	yes lingual	Ceramic insert
CElliot	1101c	Tofflemire	Flexible circumferential 0.035 mm	yes lingual	Elliot separator
Walser	Walser matrix O-form No 10	Incorporated	Flexible circumferential 0.05 mm	no	Incorporated spring

for 40 seconds from an occlusal direction, while maintaining mesial pressure on the insert.

Proximal contact tightness was measured immediately after placement of the restoration using the Tooth Pressure Meter, TPM, (University of Technology, Delft, The Netherlands), a device described by Dörfer and others[1] and Loomans and others.[3] This instrument measures the PCT as the maximum frictional force (N) exerted on a 0.05 mm thick metal strip upon withdrawal from the interproximal area in an occlusal direction. In order to standardize the direction of insertion and withdrawal of the metal strip, the manikin model and TPM were mounted in a custom-made stand as shown in Figure 4.

Three measurement procedures were performed for each restoration. The final result of each measurement was the mean of these three consecutive measurements. A measurement failed when the outcome exceeded the maximum (pre-set) range of 0.5 N among the three measurements, for example, due to deformations of the strip or a non-parallel removal of the strip from the interdental area. This measurement was then excluded from the data and repeated. Custom-written software in Excel (MS Office 2000, Windows) was used for data acquisition and the construction of diagrams relating force to seconds. The data were analyzed using SPSS (SPSS 15, Inc, Chicago, IL, USA). One-way ANOVA, followed by the post-hoc Tukey test, were used to identify statistical differences between pairs of means. Statistical significance was set at p=0.05 for all tests.

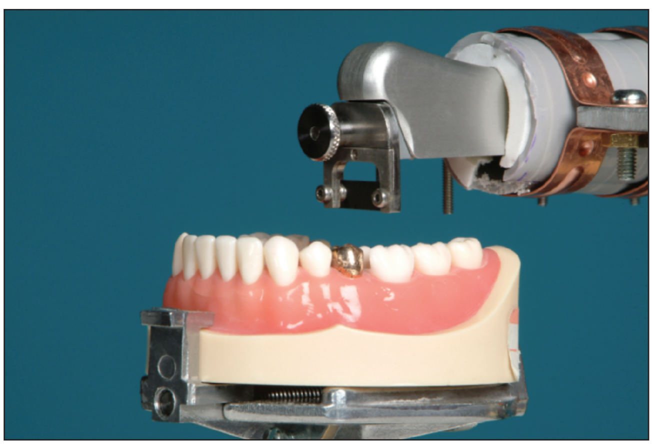

Figure 4: *Measurement of PCT using the TPM.*

RESULTS

The mean, standard deviation and 95% confidence interval (95% CI) of the seven techniques used to restore the proximal contact are outlined in Table 2. Compared to the control group (SRing) (6.64 ± 1.06N), all the other systems resulted in statistically significant lower PCT values (for all comparisons: p<0.001), as shown in Figure 5. Within the circumferential matrix groups, the CRing (4.01 ± 0.53N), as well as the CElliot (4.29 ± 1.08N) groups, resulted in statistically significant tighter contacts compared to the CWedge (0.37 ± 0.22N), COptra (0.91 ± 0.49N), CCerana (2.99 ± 1.98N) and Walser matrix (1.34 ± 0.55N) group (p<0.05). No statistically significant difference was found between CWedge and COptra (p=0.57), nor between CRing and

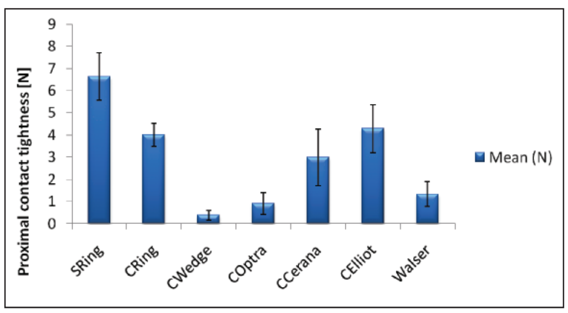

Figure 5: *Chart showing mean PCT (N) for all test groups.*

Table 2: *Mean, Standard Deviation (SD), Standard Error of Mean (SEM) and 95% Confidence Interval for Test Groups*

Test Group	Mean (N)	SD	SEM	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
SRing	6.64[d]	1.06	0.27	6.06	7.23
CRing	4.01[c]	0.53	0.14	3.72	4.31
CWedge	0.38[a]	0.22	0.057	0.25	0.5
COptra	0.91[a,e]	0.49	0.13	0.64	1.18
CCerana	2.99[b]	1.28	0.33	2.28	3.7
CElliot	4.29[c]	1.08	0.28	3.69	4.89
Walser	1.34[e]	0.55	0.14	1.04	1.65

Different characters (a-e) are used to mark the tested groups with statistically significant differences (p<0.05).

the CElliot groups (p=0.970). The Walser group produced results that were not statistically significant from the COptra group (p=0.781). The CCerana group showed an intermediate PCT value of 2.99 ± 1.28N, which was significantly higher than the COptra (p<0.001) and Walser group (p<0.001).

DISCUSSION

In the current study, the cavity preparation was designed to simulate a clinical condition where an old moderate-sized amalgam filling was removed. A wide proximal cavity preparation was thus obtained, which presented a greater challenge to both the operator and the restorative techniques with regards to proximal contact reconstruction. The *in-vitro* setup used in the current study was constructed to resemble a setup that has been previously used in several studies and shown to produce clinically relevant results.[19,26] The setup allows an orientation of the manikin model to ensure near parallel insertion of the metal measuring strip into the contact for each restoration.

As shown in the results of the current study, all tested systems did not produce contact tightness comparable to the "gold standard," in which a sectional matrix system was combined with a separation ring. Therefore, the hypothesis (H_0) has to be rejected due to the significantly higher PCT values obtained with the control group compared to the test groups (p<0.001).

The intra- and inter-individual variation in contact tightness is very large and, therefore, an optimal value for contact tightness cannot be given.[1-3] Thus, the question of "how tight a proximal contact should be clinically" is difficult to answer. However, several researchers have concluded that proximal contact after restoration should be comparable in tightness to the situation before treatment.[3] A six-month clinical study by Loomans and others indicated that an increased PCT after treatment tends to loosen over time, while a reduced PCT after treatment improves over time, though remaining significantly weaker.[2] This finding implies a strong proximal contact may lead to the most satisfactory clinical results.

Among the circumferential matrix groups, the lowest PCT value was obtained when no separation (CWedge) was employed and the highest value was obtained when a separation ring (CRing) was utilized. These results confirm the importance of separation for obtaining a superior PCT when placing Class II resin composite restorations. These findings are in accordance with the results obtained in a study by Loomans and others.[26] Separation rings create separation force vectors at the height of the proximal contact, which remains stable as long as the ring remains activated, while wedges produce elongation and/or rotation rather than real separation.[13]

In an attempt to provide tighter contacts using a circumferential matrix, pressure on the matrix band against the neighboring tooth during polymerization of resin composite has also been investigated. Numerous techniques based on this principle have been advocated, such as pronged hand-instruments, conical light cure tips and prefabricated inserts.[18-20,26,29] The current study demonstrated a poor performance by OptraContact hand-instruments (COptra), resulting in a contact tightness that was not significantly different from the circumferential matrix, where only a wedge was used. These findings contradict the findings of previous *in-vitro* studies that found a slight, nevertheless significant increase in PCT when hand-instruments with wedges were used compared to using wedges only.[18-19] This difference in results may be attributed to the more rigid nature of the connection between the artificial tooth and manikin model used in the current study compared to the previous study or to a negative contour of the proximal surface of the restoration. A negative contour may be obtained due to pressure with the hand-instrument, resulting in a higher frictional force on removal of the measuring strip. However, in a randomized clinical trial, Loomans and others showed that the use of a hand-instrument with circumferential matrix resulted in a lower proximal contact tightness compared to the condition before treatment.[3] Among the techniques used to increase PCT with circumferential matrix bands is the insertion of prefabricated ceramic inserts. The results of the current study showed that the use of ceramic inserts (CCerana) significantly increases the PCT of the circumferential matrix and wedge-only group (CWedge). A similar finding was also found by El-Badrawy and others.[18] However, the contact tightness is still weaker when compared to the "gold standard." The advantages of the ceramic insert technique include lower polymerization shrinkage, as less resin composite is used,[30] and their versatility in wide proximal cavities. Moreover, the use of Cerana inserts has been shown to significantly reduce gap formation between resin composite and the tooth.[31] Short-term clinical studies confirm *in vitro* findings regarding improved marginal adaptation and increased wear resistance.[30] However, there is an increased risk of marginal overhangs and poor resin-to-insert adaptation. The resin-insert bond may be jeopardized due to surface contamination of the insert.[32]

Although the use of ceramic inserts did improve the contact tightness, the results of the current study demonstrated that the greatest increase in tightness was found in the groups that utilize teeth separation techniques. This indicated that the provision of greater interdental separation forces will result in tighter contacts, especially when a sectional matrix is used. The significantly higher contact tightness for the sectional matrix over the circumferential matrix when a separation ring is utilized clearly demonstrates the role of the matrix band thickness compensation by the separation ring. The placement of a circumferential matrix band doubles the thickness of the matrix that has to be compensated for, since it passes through both contacts as opposed to a sectional matrix band that only passes through the contact to be restored. Thus, greater separation is required to compensate for increased matrix band thickness when circumferential matrix bands are employed.

The results of the current study demonstrated that the Elliot separator resulted in separation that was not statistically significantly different from the separation ring when both were used with a circumferential matrix. This indicated that the amount of separation achieved using the Elliot separator was capable of achieving a PCT equivalent to clinically proven techniques—that is, separation rings. Further investigations are required to determine the clinical usefulness of this device.

The performance of a newly introduced matrix system, the Walser matrix, was tested. The manufacturer claimed that this system provides tight proximal contacts. However, the performance of the matrix used in the current study was inadequate. This is believed to be due to the weak springing action of the retainer. The system does not provide sufficient interdental separation and relies mainly on adaptation of the matrix band to the neighboring tooth. However, due to the relatively rigid attachment of the teeth, the fact that the Walser matrix might be more efficient in clinical situations with weaker physiological contacts cannot be excluded.

CONCLUSIONS

Within the limitations of the current study, it can be concluded that

- Sectional matrix systems combined with separation rings still provide the greatest proximal contact tightness when placing two-surface Class II resin composite restorations compared to several new available matrix systems.
- Use of a wedge and/or hand-instrument only to obtain interdental separation is insufficient.
- A newly introduced system, the "Walser matrix," does not provide tight proximal contacts despite the good proximal contour it provides.

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