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In vitro Comparison of the Efficiency of Celluloid and Metallic Matrices in Proximal Restorations with a Bulk Polymer-based Biomaterial

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***Abstract**: The purpose of the study was the comparison of the contact tightness of the restored proximal area of lateral teeth with celluloid and metallic matrices and a bulk polymer-based biomaterial using an original* in vitro *assessing method.In 300 plastic right upper molars, mesial and distal vertical boxes (4 mm width in all directions) were prepared. 150 teeth were restored using circumferential celluloid bands and the rest were restored with sectional metallic saddle bands with the same thickness. The mesial/distal contact tightness was measured, before preparations and after restorations using dental floss and an original system consisting in a dynamometer connected to the model fixed on a plate that could slide gravitationally on vertical metallic rails actioned by a mass of 850 g attached with a string. The passing through force was recorded. For the mesial surfaces, the force varied from 4.782 ± 0.014 N (sound) to 5.086 ± 0.011 N (restored) ($p < 0.05$) for circumferential celluloid matrix while for the sectional metallic matrix, the values varied from 4.787 ± 0.016 N (sound) to 5.596 ± 0.01 N (restored) ($p < 0.05$). For the distal surfaces, the force varied from 5.589 ± 0.01 N (sound) to 4.777 ± 0.011 N (restored) ($p < 0.05$) for circumferential celluloid matrix while, for the sectional metallic matrix, the values varied from 5.586 ± 0.012 N (sound) to 5.793 ± 0.015 N (restored) ($p < 0.05$). Comparing to the sound surfaces, the bulk polymer-based material with high consistency and the circumferential celluloid matrices generated poorer distal and slightly stronger mesial contact area tightness while the sectional metallic ones drove to stronger mesial and distal contacts. However, the celluloid bands are often preferred because they allow the photopolymerization process and permit a good visual control during most of the steps of the working protocol.*

***Keywords**: plastic and metallic matrices, polymer-based biomaterial*

1. Introduction

Restoring the proximal surfaces of the posterior teeth has always encountered different challenges regardless of the theoretical background and the practical training. This may be due to the fact that the natural proximal morphology of teeth is usually difficult to restore even with proper technique, materials and skills.

The tightness of the contact areas on natural teeth plays a very important role in the periodontal integrity and the continuity of the dental arch preventing from food impaction, periodontal troubles, tooth movement or caries [1-3]. It has dynamic features depending on the tooth, time of the day, the position of the patient or restorative methods. Measurements have indicated that its value varies, decreasing from posterior to anterior direction [4].

A correct restoration of the proximal surfaces implies the right working protocol, correctly adapted to the characteristics of the clinical case.

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Good selection of the conformation system, wedges and restorative biomaterial are a good start for a successful outcome.

The conformation systems are, generally, made of a retainer and matrix bands. They are often separated, with autoclavable retainer and single-use matrix or they are presented in single-use all-in-one systems. An ideal matrix is thin, stable, easy to be applied, contoured, transparent, colored and with low deformation risk. Today, they are made of different materials (metal, plastic, others) and they are sectional or circumferential [5, 6]. Compared to the metallic ones, the plastic matrices are transparent but thicker and with higher risk of deformation. Each feature plays an important role but the curvature and thickness of the matrix are essential, the extent and degree of convexity of the future contact area being their direct consequence.

The wedges also play a very important role. They are used at the beginning of the protocol for treatment clinical situations without extensive loss of proximal tissues in order to separate the teeth before preparation of the cavities (for compensating the thickness of the matrices) [5, 7]. Then, they are used during the restorative stage, adapting the matrix against the rest of the proximal surface. They come in various shapes and they are made of different types of wood or plastic materials with various elasticity and transparency. When they are made of plastic, they can be transparent or not and they, usually, have a high degree of elasticity, being very adaptable to the curves of the proximal surface. The number of wedges also depends on the features of the tooth preparation [5]. Considering all these aspects and depending on the clinical situation, flexible, curved or waved wedges would be good choices for a proper marginal sealing of the future restoration [5].

The separation of the teeth with large loss of proximal tissue cannot be properly done using wedges and, that's why, the protocol for large proximal restorations on lateral teeth may also involve the use of special hand instruments, with active ends made of plastic or metal, used within the restorative stage [8, 9].

The recommended biomaterials for restoring proximal boxes with occlusal opening have specific mechanical properties, the reconstruction of the marginal ridge needing high resistance to wear and pressure. The adherent biomaterials are divided into three categories based on their mechanism of retention to the dental tissue: the glass ionomer cements have a chemical connection, the composite resins have a retention through adhesion and the hybrid materials (compomers, giomers, resin-modified glass ionomers) have a mixed mechanism. The polymer-based materials have different consistencies and two main ways of application which are consequences of the value of the polymerization shrinkage. One of them implies the application in successive, 2 mm thick, inclined layers with no connections between two opposite walls and, the other one is represented by the bulk application, with thicker layers and connection between opposite walls. According to El-Shamy et al. bulk composites with high viscosity and composites that use sonic energy to low their consistency during placement generated restorations with tighter contact areas than the flowable ones [10]. So, bulk resin composites, giomers or compomers with high viscosity and glass hybrid ionomer cements are good choices for these clinical situations. A low polymerization shrinkage and low intensity curing units have, also, proven to be recommended for a good tightness of the contact area [11].

The products are various today, the key of the right choice being held by the practitioner whose decision should mainly depend on the features of the clinical case, knowledge and skills.

The quality of the newly restored proximal areas and its evolution in time is evaluated through the assessment of the marginal sealing and of the correct morphology of the proximal surface. A correct vertical, sagittal and transversal configuration of the proximal wall drives to an initial proper tightness of the contact area with the neighboring tooth which is essential considering the fact that the intensity of the tightness decreases in time [1, 2].

So, the evaluation of the proximal tightness of the contact areas is very important at the end of the restorative protocol and, in time, during periodical check-ups.

The only frequent clinical technique of assessment has proven to be the use of the dental floss, a proper contact consisting in passing through with a certain acoustic snap. Teich et al. showed that the

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results depend on the type of the dental floss, no matter of the experience of the practitioner [12]. However, it is obvious that this *in vivo* method has a high degree of subjectivity.

Still, several methods, implying techniques and instruments/devices have been used to assess *in vitro* or *in vivo* tightness of the contact areas but they didn't prove to have in office, frequent, clinical applicability.

One of the method implied the use of a device which measured the frictional force used to pull out horizontally a metal strip inserted in between two teeth with proximal contact with a spring movement. The contact tightness was measured in N and it was calculated, then, as being the ratio between the measured frictional force and 2μ [13].

A digital tension transducer was also developed to measure the frictional force when pulling a 0.03 mm-thickness metal strip through the proximal area [14] and a device that had a digital strain gauge which turned the frictional force into compressive force using a hinge was imagined, too [15].

Dorfer et al. also developed a device whose metal strip of 0.05 mm-thickness was fixed in a special holder with strain gauges to register the bending action of the holder during the withdrawal of the strip [16].

Another method involved a measuring device with sensor, motor, body and measuring section. A metal strip was pulled out from between the teeth with a constant speed of 8 mm/s. The peak value of the frictional force which was recorded during removal was considered the contact tightness [17, 18].

The Tooth Pressure Meter is the device that several studies on the subject have used over the years [10, 19-21]. It has been invented at the University of Technology Delft (Netherlands) according to the principles of Dorfer et al. [16]. Having similar principles, Tolba et al. used a universal testing machine (Instron model 3345) which recorded the maximum frictional force for withdrawing a 0.05 mm thick steel strip from the contact area [22].

The purpose of our *in vitro* study was the development of a new method of evaluation the tightness of the proximal contact areas through the comparison of the restored mesial and distal walls of an upper molar with two types of matrix systems and the same wedges and bulk polymer-based biomaterial.

So, our first null hypothesis is that the same biomaterial and both matrix systems help obtaining contact areas with the same tightness as that of the sound areas and the second one is that both systems generate contact areas with the same tightness.

2. Materials and methods

300 right upper molars from a screw fixed teeth and soft gum teaching simulation model 8011 (Anatomika) on a dental phantom head and several instruments and materials were used within the study (Figure 1). All teeth were tightened with a force of 15 N using a torque wrench.

Before preparation, each molar was separated from the neighboring teeth with one small, natural-colored triangular birch-wooden wedge (Directa) for each proximal surface, applying them in turn, as the cavities were prepared, first in the mesial oral embrasure and, then, in the distal oral one. The same type of wedge was used during the restorative stage, too.

(a) (b)

Figure 1. The articles used in the study: (a) dental phantom head; (b) instruments and materials

For each molar, both mesial and distal vertical boxes with 4 mm width in vertical, transversal and sagittal directions were prepared by only one operator using round carbide bur for excavation (medium speed) and red abrasive cylinder rotative instruments (medium speed) as finishing instruments for the edges. The boxes had round inner architecture and the edges were leveled, with round corner exterior angles.

For each cavity, a tool for measuring the thickness of dental crowns (Iwanson type) was used to mark the limits of the preparation. In order to maintain a constant opening of 4 mm between the instrument's tips was created a stopper with light-cured resin (Figure 2).

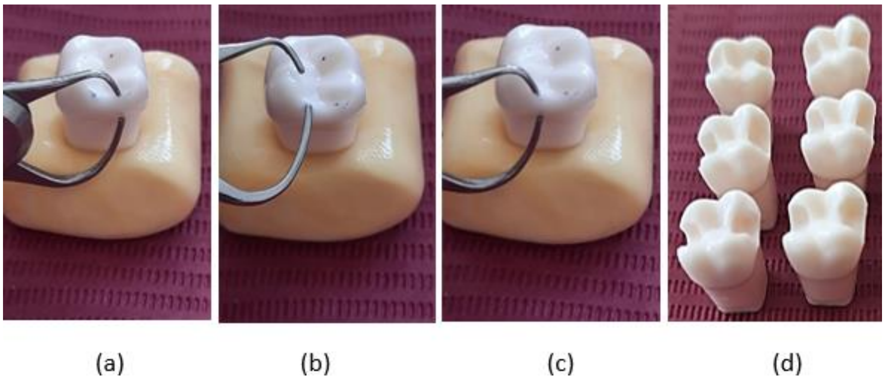

Figure 2. Preparation of the cavities: (a-c) measurements with the Iwanson type instrument; (d) a group of teeth with mesial/distal boxes

The teeth were divided into two groups according to the proximal restoration technique to be used. First group used a single-use matrix system with a 0.050 mm thickness circular plastic band (Adapt SuperCap® Matrix no.2171 (Kerr) (5 mm high blue cylinder holders). The second one used two 0.050 mm thickness sectional metal saddle bands (no.1313, shape 1 standard) (TOR VM) stabilized by the reusable Springclip no.1003 (TOR VM) (Figure 3a, b).

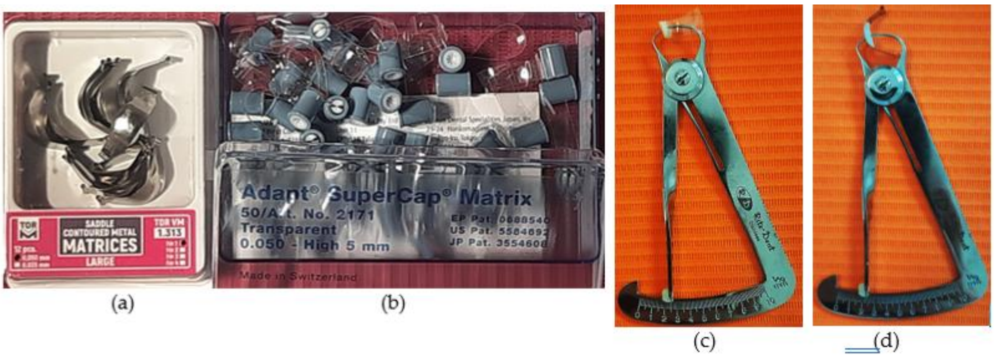

Figure 3. The matrix systems: (a) sectional metallic matrices; (b) circumferential celluloid matrices; (c) measurement of the curvature of the celluloid matrix; (d) measurement of the curvature of the metallic matrix

As their curvature wasn't mentioned in the product brochure, we measured it for each type of matrix using a flow composite (Filtek Bulk Fill Flow, 3M). The deepest area of the curvature, corresponding to the thickest zone of the material was measured using the same Iwanson type tool that was previously used to mark the limits of the preparations. The values were very close (2.5 mm) (Figure 3 c, d). After application, no burnishing of any of the matrices was done.

The cavities were cleaned with physiological serum and dried out with compressed air from an oil free compressor.

The same adhesive system (applied on micro-retentions resulted out of the preparation itself) and restorative material were used for all the boxes. Adper Prompt L-Pop Self-Etch Adhesive 3M (Table 1) was applied in each cavity according to the instructions of use. 3M™ Filtek™ One Bulk Fill Restorative (Table A1) was applied in 4 mm layers. Both, the adhesive system and the restorative material were cured using a LED curing light lamp (Premium Plus-BlueTech, CO2-M Mini LED, 440-480 nm, max.power 1200 mW/cm^2) from occlusal, oral and buccal direction, for 5 and 10 s, respectively. Every time, the ball and chisel non-stick attachment shapes of Optraculpt (Ivoclar Vivadent) were used to apply the filling material.

At the end, before measurements, no finishing procedures were done.

All the restorations were made by the same practitioner, in standardized conditions.

Table 1. The composition of the adhesive system and filling material

Material	Ingredients	C.A.S. No.	% by Wt	Manufacturer
3M™ Filtek™ One Bulk Fill Restorative	Silane Treated Ceramic	444758-98-9	60 - 70 Trade Secret *	3M Company
	Aromatic Urethane Dimethacrylate	1431303-59-1	10 - 20 Trade Secret *	
	Diurethane Dimethacrylate (UDMA)	72869-86-4	1 - 10 Trade Secret *	
	Silane Treated Silica	248596-91-0	1 - 10 Trade Secret *	
	Ytterbium Fluoride (YbF3)	13760-80-0	1 - 10 Trade Secret *	
	Water	7732-18-5	< 5 Trade Secret *	
	Silane Treated Zirconia	None	< 5 Trade Secret *	
	1,12-Dodecane Dimethycrylate (DDDMA)	72829-09-5	< 2.5 Trade Secret *	
	Ethyl 4-dimethyl aminobenzoate (edmab)	10287-53-3	< 0.3 Trade Secret *	
Adper Prompt L-Pop Self-Etch Adhesive 3M	Water	7732-18-5	70-80 Trade Secret *	
	2-hydroxyethyl Methacrylate	868-77-9	20-30 Trade Secret *	
	2-propenoic Acid, polymer with methylenebutanedioic acid	25948-33-8	< 2 Trade Secret *	

*The specific chemical identity and/or exact percentage (concentration) of this composition has been withheld as a trade secret.

The mesial/distal contact tightness was measured on the sound molars (before any preparations) and after the restorations using dental floss and an original custom-made system that we designed for this study.

All the measurements were made in standardized conditions by the same two operators who weren't aware of the type of the matrix that had been used.

The system we made consisted in:

- a dynamometer Sauter FK 10, 10 N (Kern) (Table 2) attached to a thick melamine sheet fixed to the wall, the vertical position being checked with a Mini Digital Protractor Inclinometer Electronic Level.

Table 2. The dynamometer's specifications

Product	Sauter FK 10, 10 N
Manufacturer	Kern
Type	Digital
Maximum capacity	10 N
Indication	0.005 N
Accuracy	0.500 %
Overload protection	200 %

Functions	Automatic shutdown Function for maintaining the maximum measured value (Peak Hold) *
Power supply	100 V- 240 V
Screen	Display with automatic identification of the reading direction
Accessories included	90 mm extension rod
External dimensions	195*82*35 mm
Ambient conditions of use	Maximum operating temperature: 30 °Minimum ambient temperature: 10
Product code	FK 10

- a perpendicular rectangular plate, that slides on the two parallel vertical metallic rails and has a custom system for fixing the model. The Mini Digital Inclinometer was applied before each measurement on the plate to keep a correct spatial relationship between the horizontal plate and the dynamometer (Figure 4).

Figure 4. The dynamometer and the digital inclinometer

- a mass of 850 g, which provided the constant downward vertical traction force, was suspended with a 5 cm long string from the horizontal plate.

2 marks were made on the plate to set the two positions (where the dental floss had a vertical position in) for the mesial and distal embrasure, respectively. The model was fixed every time, with a screw on the horizontal plate adapted to these marks so the measurements to be made under the same conditions, for each tooth, for each proximal unprepared surface and each proximal restoration.

The dental floss used within the study was waxed and expandible (Sensodyne Expanding Floss) (Table 3). A new 5.5 cm long loop of dental floss was used every time a new measurement was made.

Table 3. The components of Sensodyne Expanding Floss

Product	**Components**
Sensodyne Expanding Floss	Nylon 6 Microcrystalline Wax PEG-32 Copolymer of Ethylene Oxide and Propylene Oxide or Poloxamer 407 Vinyl Acetate/Ethylene Copolymer Aroma PTFE Aqua PEG-8 Sodium Fluoride Sodium Saccharin Mint flavor Active ingredient: sodium fluoride 0.03%

A new screw was also used every time a tooth was placed into the model.

A stamp occlusal key of the sound and of surrounding teeth was made every time prior to cavity preparation so that the repositioning of the tooth with restorations to be done correctly.

The protocol of measuring was as follows: a loop of dental floss was first inserted interdentally, then it was hung on the hook of the dynamometer, the entire model-horizontal plate system being manually maintained until the moment when the dental floss was stretched down and the dynamometer display still showed 0.000 N. The entire system (model + plate) was, then, allowed to fall by gravity, the dynamometer being set on the peak hold mode. In this way, the maximum force required to pull the dental floss through the analyzed interdental space was recorded (Figure 5).

(a) (b) (c) (d)

Figure 5. The protocol of measuring the passing through force:
(a, b) distal surface; (c, d) mesial surface

Each right upper molar passed the following protocol steps:

- the mesial/distal contact tightness was measured using the dental floss and the custom-made system described above;
- mesial and distal boxes were prepared using the protocol above;
- the boxes were washed with serum, dried out and the adhesive system was applied;
- a proximal conformation system was used with a specific restoration technique.

150 teeth were restored as follows:

- a celluloid circumferential band, type Adapt SuperCap® Matrix no.2171 (Kerr) (5 mm high blue cylinder holders), was adapted on the tooth;
- two white wooden wedges (Directa) were applied from both, facial and oral directions in the mesial gingival niche;
- the restorative material was applied mesially and cured;
- the adhesive system and the restorative material were applied distally and cured;
- the matrix was removed after restoring both preparations;
- the mesial/distal contact tightness was measured using the protocol described before (Figure 6).

The other 150 teeth were restored as follows:

- a metal saddle band (no.1313, shape 1 standard) (TOR VM) stabilized on the mesial side by the reusable Springclip no.1003 (TOR VM);
- two white wooden wedges (Directa) were applied from both, facial and oral directions in the mesial gingival niche;
- the adhesive system and the restorative material were applied and cured;

- the matrix was removed after restoring the mesial preparation;
- a new metal saddle band (no.1313, shape 1 standard) (TOR VM) was applied distally;
- two white wooden wedges (Directa) were applied from both directions in the distal gingival niche;
- the adhesive system and the restorative material were applied and cured accordingly;
- the matrix was removed after restoring the distal preparation;
- the mesial/distal contact tightness was measured using the protocol described before (Figure 7).

Figure 6. The steps of the restoring protocol with circumferential celluloid band: (a-d) restoration of the mesial preparation; (e-h) restoration of the distal preparation

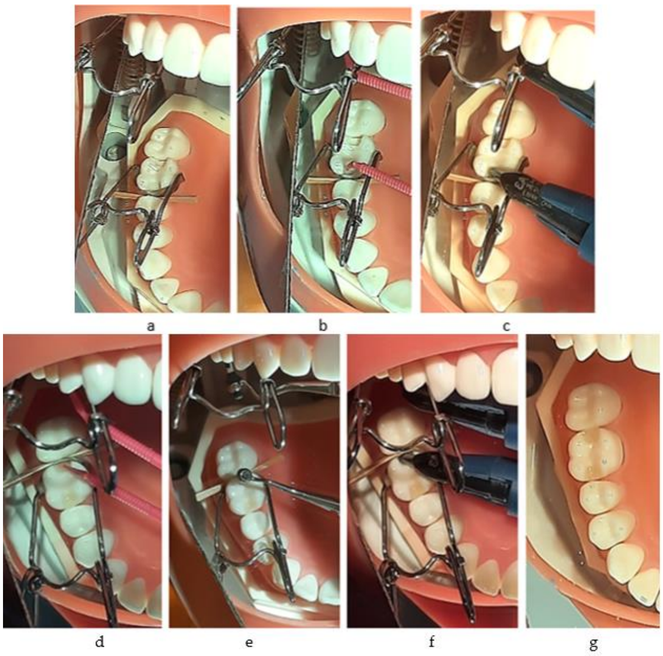

Figure 7. The steps of the restoring protocol with sectional metallic band: (a-c) restoration of the mesial preparation; (d-g) restoration of the distal preparation

Three measurements (every 5 min) were made for each sound/restored surface of the tooth.

The teeth with restorations were immersed in physiological serum in between the measurements to maintain them hydrated.

A custom composed program in Excel (MS Office Professional Plus 2021 for Windows) was used to collect data.

Statistical analysis was performed with the “R” statistical computing program (version 4.2.3 – Shortstop Beagle) using one-way ANOVA followed by Tukey’s multiple comparisons of means test to determine differences in proximal contact tightness between groups. The level of significance was set at $p < 0.05$.

3. Results and discussions

Following the measurements performed in the case of the circumferential celluloid matrix, a statistically significant increase of the passing through force of 0.304 N was noted. On the other hand, the measurements for the distal surface showed a significant decrease in the passing through force values by -0.811 N (Figure 8, Table 4).

Table 4. Comparison of proximal contact tightness when using circumferential celluloid matrix

Passing through force (N)	Sound surface Mean ± SD	Restored surface Mean ± SD	Mean Difference	P value
Mesial	4.782 ± 0.014	5.086 ± 0.011	0.304	< 0.05
Distal	5.589 ± 0.01	4.777 ± 0.011	- 0.811	< 0.05

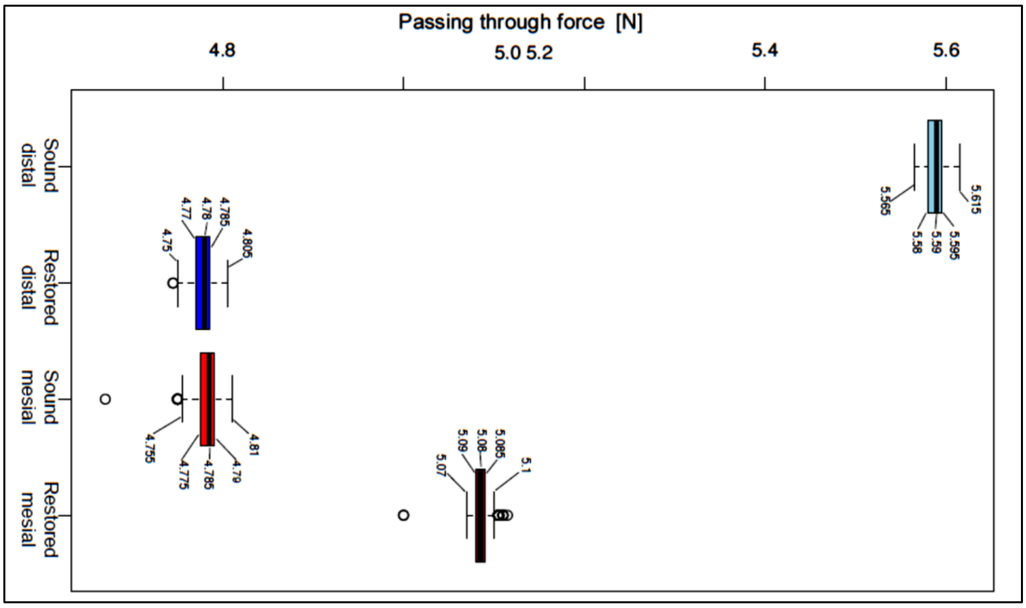

Figure 8. Passing through force in case of circumferential celluloid matrix

For the group of teeth where the sectional metallic matrix was used, statistically significant improvements of proximal contact were noted after restoring. On the mesial surface, it was recorded an increase of passing through force of 0.808 N and, for the distal surface, there was also a statistically significant increase of 0.207 N (Figure 9, Table 5).

Table 5. Comparison of proximal contact tightness when using sectional metallic matrix

Passing through force (N)	Sound surface Mean ± SD	Restored surface Mean ± SD	Mean Difference	P value
Mesial	4.787 ± 0.016	5.596 ± 0.01	0.808	< 0.05
Distal	5.586 ± 0.012	5.793 ± 0.015	0.207	< 0.05

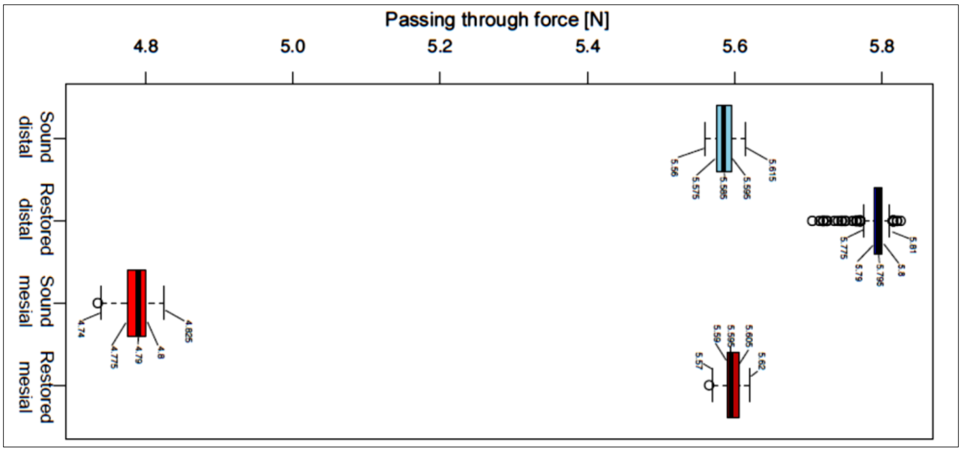

Figure 9. Passing through force in case of sectional metallic matrix

For the sectional metallic matrix, the values of the differences of the passing through force between restored and sound teeth were positive for both mesial and distal surfaces proving that the interproximal tightness of the restored teeth was higher than the one of the sound ones. The circumferential celluloid matrix generated positive difference of the passing through force between the mesial restored and sound surfaces and negative value for the distal ones proving that the interproximal tightness was higher for mesial areas and significantly lower for the distal ones (Figure 10).

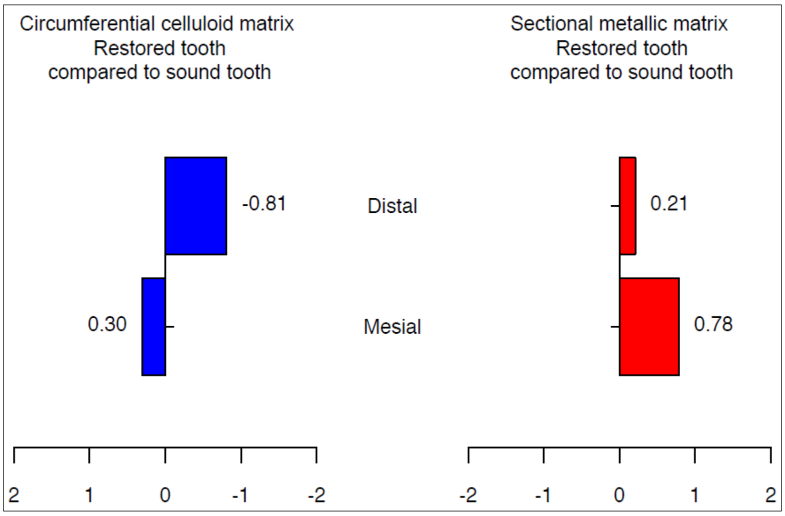

Figure 10. Difference of passing through force (N)

Even after years of experience in the practice of operative dentistry, restoring proximal surfaces still and often encounters many obstacles.

One of the most frequent deficiencies of new or older proximal restorations is the poor tightness of the contact area. In the case of the new ones, the lack of pre-wedging, high-shrinkage restorative bio-material and inappropriate choice of the matrix or wedges are some of the most important reasons.

One of the main problems of the working protocols consists in the capacity of restoring the

initial, natural, spatial curves of the proximal surface, the tightness of the contact area being essential in the tooth's long-term recapturing of its function of dispersing the horizontal components of the occlusal forces, maintaining the continuity of the dental arch and of the axial orientation of the teeth, protection of the gingival tissue and preventing from food interproximal retention which may lead to secondary caries [1, 7].

Each contact area in primary dentition has a surface with a certain dimensional extent and convexity. In time, proximal physiological attrition of the sound enamel flattens slowly, these areas generating a natural movement towards mesial. This could drive to dent-alveolar disharmony with incongruence and the shortening of the arch from a few millimeters to one centimeter [1]. Considering these aspects, it is natural to understand that a proper tightness of the freshly and old restored areas is essential in order to maintain a long-term contact of the restorative biomaterial with the adjacent proximal surface. A poor-quality of the newly restored area would soon lose its correct function and the replacement of the restoration would be required without delay.

So, assessing the tightness of the newly restored contact areas or their evaluation in time are essential for a correct decision regarding the quality of the proximal restoration.

In any circumstance, a correct sagittal, transversal and vertical conformation of the proximal surface is a difficult task and depends on several factors, the matrix system being, of course, one of the most important "actors". Every type of matrix band has advantages and disadvantages, its thickness, risk of deformation, degree of curvature, ease of application, contribution to the overall amount of time of the procedure being essential pieces of the puzzle of a correct restoration.

In our study, we used sectional metallic bands and circumferential celluloid bands with the same thickness (0.050 mm). We also measured their maximum curvatures that weren't mentioned in the product-brochure, the values being very close (2.5 mm). Considering that burnishing of the bands may generate super extended contact areas, we acted accordingly within our study.

In our study, we used one wedge in order to separate the teeth before preparation and, During the restorative stage, the wedges, with the same dimension with those used for separation, should adapt properly the matrices to the rest of the proximal surface. At this point of the working protocol, the types and number of wedges are very important. In our study we used two straight wooden wedges in all the situations. When using the circular celluloid matrix, we kept the wedges in both mesial and distal embrasures until the end of the restorative stage because we considered that, at this point, in a correct positioning, the wedges simply adapt the matrix without further separation.

So, regardless of the theoretical working protocol, the right choice of the instruments, accessories or restorative biomaterials, is clearly indicated by the features of the clinical case.

The only practical way of clinical assessment of the newly and old restored areas has proven to be the use of the dental floss which is supposed to pass through the restored contact area with a certain snap.

There is a wide range of dental flosses, made of nylon or polytetrafluoroethylene, waxed or unwaxed and it is natural to assume that the proximal contact tightness varies along with the product [12].

So, in our opinion, the dental floss to be used for *in vitro* and future *in vivo* measurements should be the one that the practitioner advises the patients to use in their daily dental cleaning routine. Considering the expandible flosses as being very efficient in removing unwanted deposits from the gingival embrasure, we used Sensodyne Expanding Floss in the study. This is a microcrystalline waxed and expandible dental floss, made of nylon 6 and other components.

When using the circumferential celluloid matrix, the results indicated that, comparing to the sound surfaces, the restorative protocols, led to restorations with slightly stronger mesial and poor distal contact area tightness.

When using the metallic sectional matrix, comparing to the sound surfaces, the restorative protocols, drove to restorations with much stronger mesial contact tightness while the distal areas had slightly stronger contact.

It is, also, noticeable that, using both types of matrices, the newly restored mesial contact areas had stronger contacts than the sound ones, the sectional matrices creating, comparatively, much stronger mesial contacts than the circumferential one.

For the distal restored surfaces, the sectional metallic matrices continued the trend of creating stronger new contact areas but with a much lower difference compared to the sound surfaces than for the mesial areas. The surprise was set by the distal areas restored with circumferential celluloid band because the passing through force recorded a mean value much lower than the one established after evaluating the sound surfaces. The reason for these values may be the fact that, after restoring the mesial box, the circular band is kept in place and a certain degree of separation still exists.

So, the results indicated that both matrix systems helped generating contact tightness with values different from those of the sound surfaces and they, also, indicated that the circumferential matrix led to poorer values on the distal surfaces than the sectional one.

So, our first null hypothesis was rejected, both matrix systems generating contact areas with different values of tightness than those of the sound areas. The second one was also rejected, the two systems developing contact areas with different tightness.

Several *in vitro* [19, 22, 23] and *in vivo* [24] studies evaluated the efficiency of sectional versus circumferential matrices when restoring only one proximal surface. The results indicated that the sectional matrices generated tighter contact areas than the circumferential ones. However, these results should be expected when restoring only one proximal surface using a classic, circumferential band, without a fenestration on the side of the sound proximal contact area.

Similar to our study, when restoring *in vitro* both proximal surfaces of a tooth, Saber et al. also recorded a very poor distal contact after using matrix bands on both proximal surfaces simultaneously [21]. A different situation occurred after the results of Wirshing et al. who found no statistically differences when restoring *in vivo* mesial-occlusal-distal cavities with sectional and O-shaped matrix systems [25].

Analyzing comparatively our values for the tightness of mesial and distal contact areas, the distal restored areas had poorer contacts for both systems. After *in vivo* measurements for the areas between all teeth, Kyoung-Hwa Kim et al. set a mean value of 1.73 (± 0.62) of the distal contact of the first right upper molar and 1.94 (±0.76) for the mesial contact [18]. Therefore, the mesial contact was, also, stronger than the distal one.

Considering the clinical implications, the *in vivo* stronger contacts are acceptable as they loosen in time [24] and they are considered technically correctable with minimal intervention. In the meantime, the poor ones or the lack of contact should imply the immediate replacement of the restoration as unwanted consequences like periodontal problems or caries are about to appear in a very short period of time.

Obviously, the subject remains open to further *in vitro* and *in vivo* investigations. Their results and conclusions would be very important and would surely help and give tips to the operators in order to choose the right combination of instruments, accessories, dental materials and working techniques for achieving proper proximal configuration.

4. Conclusions

Compared to the sound proximal surfaces, the circumferential celluloid matrices were involved in restorations with poorer distal and slightly stronger mesial contact tightness while the sectional metallic ones drove to stronger mesial and distal contacts when using a bulk polymer-based biomaterial.

However, the celluloid bands are often the first choice for many practitioners because they allow the photopolymerization process and they, also, permit a good visual control during most of the steps of the working protocol.

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