DISCOVERY OF STRESS DURING ANCHORING OF THREADED DEVICES WITH THE HELP OF PHOTOELASTICITY AND TENSOMETRY

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Keywords: *endodontic treatment, stress, fissure, fracture*

Abstract: *To restore the teeth with endodontic treatment, most practitioners use small corono prefabricated root. Restoration of coronary stump is made by means of restorative materials (plastics). The literature abounds in this respect the materials and techniques. The present study's objective was to observe the in vitro mechanical stress behavior (axial and oblique pressure, and traction resistance) of a number of teeth roots endodontically treated and restored using the post and core system.The coronary post was restored using prefabricated DENTATUS devices, Silver Amalgam, Miracle-Mix, Culmat, Dyract, 3M VITREMER and a compomer. A parallel direction that the study took was the observation of the strength and behavior of these materials in wet conditions as opposed to their resistance in a dry environment. This stage of the study took 8 days.*

Cuvinte cheie: *tratament endodontic, solicitări, fisuri, fracturi*

Rezumat: *Pentru restaurarea dinților cu tratament endodontic majoritatea practicienilor folosesc dispozitive corono-radiculare prefabricate. Refacerea bontului coronar se face cu ajutorul unor materiale de obturație (plastice). Literatura de specialitate abundă în acest sens de materiale şi tehnici. Lucrarea de față şi-a propus să studieze comportamentul in vitro la solicitări mecanice (presiuni în ax, oblice şi tracțiuni) a unui număr de rădăcini tratate endodontic. Bontul coronar a fost refăcut cu ajutorul dispozitivelor DENTATUS, amalgam de Argint, Miracle-Mix, Culmat, Dyract, 3M VITREMER şi un compomer. De asemenea s-a mai studiat duritatea şi comportamentul în mediu uscat şi umed timp de 8 zile a acestor materiale.*

INTRODUCTION

Crown substitution, nowadays known under the title: Restoration Method for teeth with endodontic treatment has evolved unlike any other prosthetic treatment method in three distinct periods.

The First stage is the creation and design of the substitution crown by RICHMOND and the second is the modified substitution crown.

Both restorations have some disadvantages that have become major over time and thus paved the way for the two stage coronary substitution, or, more correctly said restoration of teeth with endodontic treatment with a cast root anchored device, in association with a total coverage fixed prosthesis.

Thanks to the progress of science and dental products industry, we have entered the fourth phase in which the practitioner has at hand prefabricated root anchored devices, which are associated with a material for reconstruction of coronary die and then a total coverage fixed crown.

Because of the many advantages this process has gained a lot of ground but there is a danger that practitioners will use indiscriminately.

This may be due to ignorance of treatment indications and counter indications, or due to the wide variety of such devices. Also, because each manufacturer tries to provide improvement over previous devices, we assume that the aggregation technique of the device presents a certain amount of risk to the reliability of the restoration in time, since these devices are subject to normal or pathological occlusal forces. This means that during aggregation in the root canal, or later, tissues (dentin) may be subject to compressions, fissures or even fractures.

STUDY'S OBJECTIVE

The present study's objective was to observe the in vitro mechanical stress behavior (axial and oblique pressure, and traction resistance) of a number of teeth roots endodontically treated and restored using the post and core system.

MATERIAL AND METHOD

As the number of devices and the shape of the root portion varies to a certain degree, in this paper we decided to study phenomena that may occur in the dentine during aggregation of the "Dentatus" prefabricated threaded device which is widely used in many dental practices.

These devices have parallel walls, a conical tip, threads, retentive head, and are found in assorted kits that offer six diameters, four lengths and two keys for the aggregation. These devices correspond to six drills for canal preparation, triangular in section. Diametrically the preparation obtained is slightly larger than the corresponding device. Canal preparation is made using drills in successive order. The devices are cemented although there is no cement overflow canal.

To verify that the above reasoning has a realistic scientific support we appealed to photo-elastometry techniques.

Photo-elastometry is an experimental method by which one can highlight areas of tension and deformation.

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It is based on accidental bi-refirngency property of materials. (Figure 1)

A polarized monochromatic light wave must pass through a rectangular shaped photo-elastic element (high elastic sensitivity) the incidence of the light must be at a different angle related to the direction of the main tension. Vibration decomposes after birefringence following the preferential directions in the two components isochrones and isoclines.

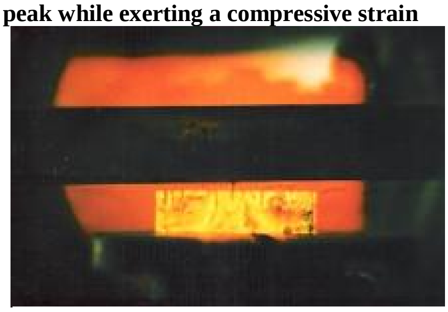
Figure no. 1. Dinox photoelastic plate, in which slots were prepared for Dentatus tooth anchored devices.

The isocrhone component can easily be seen as colored strips, more intense and more frequent as the tensions are higher. Together with Timisoara Faculty of Mechanics we undertook the following experiment:

We choose a rectangular Plexiglas plate high with elastic sensitivity (Swiss manufacturing). We found traces of manufacturing tension stored in the plate. Under a polarized lens, using globular burs, we created depressions on the upper part of the plate for the anchorage of the prefabricated Dentatus devices. During these maneuvers we observed the apparition of the izochrone components around the depressions, their density increasing proportionally to the pressure applied to the hand piece.

After this step we proceeded to inserting the prefabricated Dentatus devices, without use of any kind of cement. (Fig. 2)

Figure no. 2. Isoclines and izochrone appearance around the device's peak while exerting a compressive strain



During maximum screwing of the device (360 °) izochrone tensions appeared around the peak of the device. At a 90 ° counterclockwise rotation the tensions disappeared.

If we submitted the crown portion to a compressive force, gradually reaching 20 and then to 23 KgF, an increase in isochrone density was observed especially around the tip of the device.

If the force is applied obliquely on the coronal part of the device, the isochrones appear in the controlateral apical and gingival region.

All these observations have confirmed that the prefabricated devices may cause tension during aggregation in the tooth root.

The next objective of this paper was to quantify these tensions, with tensiometry.

Tensiometry consists of a set of methods and techniques that deal with measuring small deformations of bodies subjected to strains.

We used electric resistive Tensiometry – which measures the strains put on an object, using electric signals.

This is achieved using an electrical or strain gauges stamp, which converts physical deformation into electrical signals.

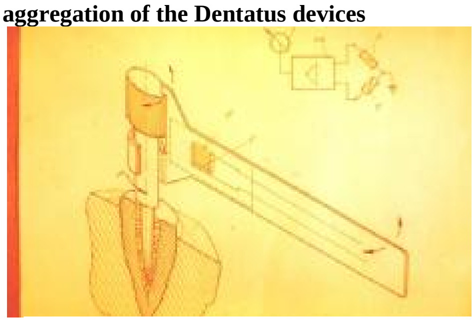
The transducer is connected to the deformation recording block also known as tensiometric bridge, through wires. (Fig. 3)

Figure no. 3. Block during recording of tension during the aggregation of a Dentatus device

In that case of our in vitro experiment, which determined tensions and the optimum momentum for the aggregation of the Dentatus device, the problem we faced was the positioning of the tension-electric resistor.

Because the teeth that were chosen for testing were implanted in acrylic blocks up to the gingival region, and the coronal portion was sectioned 2 mm above that point, we designed and developed a torque wrench calibrated in N mm. (Fig. 4)

Figure no. 4. Wrenches schematic used to record the strain during aggregation of the Dentatus devices



The key consists of a blade lever (horizontal) which has a bushing at one end, which adapts to an external smooth cylindrical portion of the Dentatus device wrench and the other end has a sharp blade. (Fig.5.)

Figure no. 5. Lot of teeth prepared for determination of stress during aggregation of Dentatus devices

The physical loading of the wrench was done by placing the wrench with the rough side on the larger end of the aggregation key. The tolerance and amplitude of the moves is limited do 20-30°, to allow the ulterior use in the oral cavity, where a full rotation would be impossible. The blade of the wrench can be repositioned as many times as we need.

Capturing the momentum (the tension) is done by fitting the two tension-electric resistors (TER) in the recording area of t1 and t2 of the lever; here the bending momentum of the wrench is maximum.

Installing the TER takes form as a Wheatstone bridge coupled to a tensiometric amplificator.

Calibration of the amplifier and of the instrument was done using certain weights (20g) that were hung from the end of the lever in a horizontal position.

The amplifier was calibrated so that the end of the scale would represent 20 Nm.

Tests were conducted on four groups of 10 periodontal single root teeth, in order to have similar experimental conditions.

Each group was composed of five recently extracted teeth and keep in saline (2-3 hours) until testing and five teeth extracted earlier and kept in 10% formalin.

All teeth were implanted in acrylic blocks up to the anatomical coronal limit.

The teeth were then sectioned at 2-3 mm above the coronal limit and were prepared in 2/3 of the root using the burs form the kit successively until drill no 3 or 4 bit depending on the diameter of the tooth.

The devices chosen were no 3 or 4 (long and extra-long) for ease of manipulation.

RESULTS

1. With the first batch the purpose was correlating the final aggregation with the indications of the measuring gauge. This device was introduced into the canal and manually rotated until the device locked in position. At that time we applied the dynamometric wrenches and we executed one or two moves of about 20-30° until we felt the final lock. This corresponds to a rotation of approx. 360.

Both aggregation and results reading was performed by the operator.

The second stage focused on collection and reading the momentum of the device at lockup, which corresponds to an unscrewing of 90 deg.

Test results are listed in Table 1.

Table no. 1. Test results

Group		Teeth	Time I	Time 2
			Rotation or locking momentum (in Nm)	**Rotation or unlocking momentum (in Nm)**
Group I	**Freshly removed teeth, kept in saline 2-3 hours.**	1	15	12
		2	12	8
		3	9	6
		4	10	7
		5	7,5	3
Group II	**Teeth preserved in formalin 10%**	1	20	14
		2	14	9
		3	6	3,5
		4	13,5	7
		5	8	5

2. Another batch of 10 teeth were prepared and tested similarly to the first, the difference was that the operator has executed aggregation and help read the results (Table 2).

3. For the 3rd batch technique we changed the aggregation technique of the device. The device was introduced vertically in the canal, and then we applied the torque wrench which we used to perform a rotation of about 45 ° and later up to 180 °.

Table no. 2. Test results

Group		Teeth	Time I	Time 2
			Rotation or locking momentum (in Nm)	**Rotation or unlocking momentum (in Nm)**
Group I	**Freshly removed teeth, kept in saline 2-3 hours.**	1	5	3
		2	6	7
		3	3	0,5
		4	2,5	2
		5	3,5	2
Group II	**Teeth preserved in formalin 10%**	1	4,5	4
		2	5	3
		3	6	7
		4	5,5	5
		5	4	2,5

Table no. 3. Test results

Group		Teeth	Time I	Time 2
			Rotation or locking momentum (in Nm)	**Rotation or unlocking momentum (in Nm)**
Group I	**Freshly removed teeth, kept in saline 2-3 hours.**	1	15	4
		2	12	6
		3	9	4
		4	10	7
		5	7,5	5
Group II	**Teeth preserved in formalin 10%**	1	2,5	3
		2	2	5
		3	3	1
		4	1,5	1
		5	1	2,5

4. On a 4th batch we used the latter technique for aggregation, but after the introduction of a phosphate cement pastes in the socket. (Table 4)

Table no. 4. Test results

Group I	**Freshly removed teeth, kept in saline 2-3 hours.**	**Teeth**	**Momentum during cementation (Nmm) at 45deg.**	**At 90 deg.**	**Unlocking**
		1	1	0	8
		2	3	0	9
		3	1	7	9
		4	2	5	8
		5	1,5	5	6
Group II	**Teeth preserved in formalin 10%**	1	1,5	3,5	6,5
		2	0,5	3	10
		3	2	5	9
		4	3	6,5	10
		5	2,5	6	9

We recorded the rotation momentum at 45° and 180 ° as well as for the de-rotation moment.

DISCUSSIONS AND CONCLUSIONS

1. First table shows that the values of the aggregation momentum range between: 7.15 and 15 Nm in Group I with one exception and 6 and 14 in group two. On de-rotation with 90 ° the values are between:

- 3 - 12 mm in Group I
- 3.5 - 14 mm in Group II

These results show a wide variation inside the same group but at the same time we see similarities between the two lots.

We conclude that the aggregation technique up to the locking moment is relative and varies from practitioner to practitioner or even with the same practitioner from time to time.

The causes may be multiple: different muscular strength from person to person, tactile perception threshold differences, influence of fatigue, stress, emotion, etc.

The structure of dental tissues is roughly the same, and does not constitute a factor relevant to these differences.

During the de-rotation the momentum value decreases but we assume it is still too high.

2. Values in Table 2 range between:

- 2.5 and 6 Nmm in Group I
- 4 and 6 Nmm in Group II at maximum rotation.
- 0.5 and 7 Nmm to harrow I
- 2.5 and 7 Nmm in Group II while de-rotating for 90 °

These values are much lower than those in Table 1 and are real.

The explanation is as follows: in the first test from the moment the operator perceived the locking moment until he moved his eyes to the gauge for the reading; there was a tendency to lose control of the muscular strength and over tighten the device.

I also noticed that the practitioner is tempted to reach the first test result. The de-rotation moment, currently, has its lowest value, so the tensions that ultimately carried by the dental tissues is greatly reduced.

3. In Table 3 values are recorded when the rotation to 45 ° takes place, the values are small, therefore the tensions are small but retention of the device is reduced.

- 1.5 and 4 Nmm in Group I
- 1 and 3 Nmm in group II

When rotating the device for 180 °, the device retention is better and the momentum values are between:

- 4 and 7 Nmm in Group I
- 1 and 5 Nmm in Group II

Comparing test results from batch 2 and 3 it is clear that the first aggregation technique gives a good retention for the device but is stressful for the dental tissues during aggregation. The second technique provides less retention of the device and exerts low pressures on dental tissues.

The natural conclusion resulting from here is that optimal final aggregation requires a rotation between 180 and 270°.

4. From table 4 we deduce the following: Tensions during the 45 ° rotation are insignificant:

- 1 and 3 Nmm in Group I
- 0.5 and 3 Nmm in Group II of

When exerting a 180 ° rotation the values range from:

- 0 and 7 Nmm in Group I
- 3 and 6.5 Nmm in group II and are similar to those in Table 2 and 3.

From here we deduce that fluid cement plays a role in tension dispersion, even if the device does not have cement overflow notches.

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