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CRDs: CAST OR PREFABRICATED?
PART III

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ABSTRACT. Teeth restored with cast or prefabricated CRDs are subject to forces during functions and parafunctions. These can be transmitted to the axis of the tooth, para-axially and even obliquely. Likewise, the intensity and duration may vary from one individual to another. In this study we focused on testing CRDs for similar strains to those at play in the oral cavity. To this end, we designed and constructed a testing machine. Conclusions are numerous, but in essence cast CRDs can no longer be eliminated from techniques using prefabricated CRDs and even less Dentatus, regardless of the abutment reconstruction material. It could only be disqualified by prefabricated non-metallic or esthetic cast CRDs, which have an elasticity mode similar to that of dentin.
KEYWORDS: CRD, strains, resistance.

INTRODUCTION

From studying the literature and from our own clinical study on 186 patients, some of which were presented in the 1st part of the research, it followed that CRD aggregation causes strains on fragile dental walls, which can crack, and during functions and especially parafunctions they come to break. This research targets cast and prefabricated metallic Dentatus CRDs.

A cast CRD is passive, dental fractures occurring mostly due to: inappropriate treatment indication, inappropriate technique for intra-radicular preparation, insufficient cervical support, or unexpected cementing.

In the case of prefabricated Dentatus devices, vastly employed in our country in recent years, we noted frequent cases of failure, the most severe of which are radicular perforation and oblique or longitudinal tooth fracture.

These devices are cylindrical-conical with a conical tip, have a screw, and the coronal portion is cuboidal, with a simple rift, or in cross, necessary for screwing. It is a screwed-on passive device, but through its shape it exerts a puncture effect on the root during aggregation, functions and parafunctions.

They are found in toolkits, in six diameters, four lengths and two screw wrenches. They correspond to special milling cutters for preparing the radicular slot.

Devices are cemented in spite of not having a discharge rift.

The purpose of the paper is to test metallic cast and prefabricated Dentatus CRDs during strains (axial or oblique compressions, torsions, tractions). For the former, the coronal abutment is metallic, and for the latter it is made of diverse restoration materials.

Some strains were physiological, but some were greater, even destroying the samples.

Does this help obtain data on the cast vs. prefabricated CRD dispute?

To this end we created a special testing machine for the above-mentioned devices, under similar conditions to those in the oral cavity.

Testing machine for compression and traction

The machine was built with several functions to be able to strain teeth under conditions as similar as possible to those in the oral cavity, or until the destruction of samples.

These functions are:

- axial compression
- oblique compression at different angles
- torsion
- shear
- resistance to fatigue (acting with cyclic intermittent, pulsating loads)
- continuous load, constant or variable, with axial action, simulating mastication, or oblique action.

The machine was designed to be charged with loads exceeding 500 kg (5 KN) at compression and 100 kg (1 KN) at tugging. The gauging precision of the load is under 100 g and can be increased when necessary. The machine is equipped with a set of accessories allowing a wide range of experiments. For axial compression one can test the resistance of a tooth or a restoration by straining on the entire occlusal surface or only of one point or limited areas. Oblique compression, torsion and shear are also strains found in the oral cavity, less tolerated than axial ones. For resistance to fatigue the machine is equipped with a DC motor, fed by an electronic variable speed drive allowing mandible movement simulation at normal frequency and "x" strokes, doubly operated per minute up to experimentally imposed regimes. The load can be fixed or variable over time. Knowing the load, a counter records the number of necessary impulses until the destruction of the sample, information which is given by a sensor in the command system, which stores all data and stops the apparatus. For this reason permanent surveillance of the machine is not necessary when it is programmed to operate with cyclic loads (mastication alternates with rest). Depending on the purpose of the experiment, the machine can be programmed to work with cyclic loads in the amount of time we desire, which can be programmed ranging from seconds to tens of hours or up to the destruction of samples (tugging, breaking, detachment). Loads applied can be intermittent or pulsating, with variable or continuous frequency. The machine was designed with accessories (tank) simulating conditions in the oral cavity (humidity, temperature, pH). Constructive description:

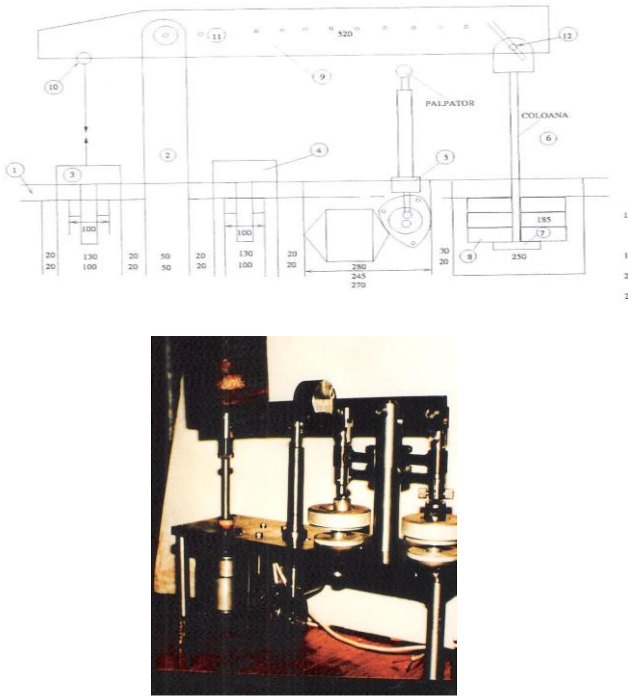

fig.1

- Base plate-1, which the column-2 traverses and where it is fixed, tables-3 and 4, touch probe guiding mechanism-5, orifice traversed by the column-6 of the fixing plate-7 of loads-8 and four 24-metric screwed holes, for fixing the apparatus' support legs. Tubular column 2, made of OLC 45, is fixed to the base plate (1) using a nut from the screw thread executed at one end. Tightening and consolidation are also possible due to the difference between the diameters executed between the rest of the column and the threaded part. In the upper part, the column has a forked frame where beam 9 is fixed using a bolt. The fork frame and the bolt hole are rectified, having a roughness of 1.6 fim to reduce friction resistance to a minimum. Through its design, the fork frame allows rotation around the axis of the fixation bolt at an angle of +/-30 degrees with respect to the resting position (horizontal). Beam 9 is made of OLC 45, being milled on the upper part in counter-slope at an angle of 2 and 5 degrees, respectively. In the body of the beam, the following are also executed: orifices to fix the mobile component of the sample tugging system 10. The beam also features an orifice for fixing mobile components of the sample compression system 11 and an orifice for fixing the fork of the support plate of fixed loads 12, with which the machine is loaded during experiments. The beam has an area scaled in millimeters, where one can read the position of the mobile load, which gives the gauging precision of loads with which the machine is charged in work regime. The load amplification ratio, calculated from the beam's support point and up to the center of the balance plate 7 is 1 to 30 kg (0,3 KN). The mobile load has 0 N above the axis of beam's fixation bolt and will exert a load of 30 kg (3 KN) above the bolt that supports the plate. Positions are given by the Vernier scale and the load by the cursor. The sample tugging device, mounted in the left side of the apparatus consists of: table 3, fixed to the base plate, and the mobile ensemble fixed to the beam (the fixed part ensuring sliding is fixed by column 2). The special construction table allows a total degree of freedom in horizontal plane, and vertically between the limits of 1-30 mm. On tugging tests no actions are necessary at certain angles.
- The compression device mounted in the right side of column 2 is also composed of a table for fastening samples in a fixed position. The table is rigidly fixed to the base plate. Various devices can be fixed to the table, with the aid of which the sample can be positioned under any angle it might be necessary. In horizontal and vertical plane, the table ensures total freedom of positioning samples within the limits of 30 mm. The mobile part of the compression device is fixed to the beam, and the fixed part that ensures sliding is fixed to column 2.
- The "touch probe" ensemble is fixed to the base plate to the right of table 4. It consists of the fixation and support column of the touch probe and the touch probe itself. This takes over the movement from a cam of a motor reducer ensemble and transmits it to the beam, which in its turn transmits it to tugging or compression devices.
- The load fixing device, situated at the right extremity of the beam, consists of: fork fixed to the beam using a bolt which ensures assembly and a mobile joint that preserves the verticality of the rod that traverses an orifice of the base plate and which is assembled into a load fixing plate.
- The motor reducer ensemble consists of: direct current motor; reducer with a 1/60 transformation ratio; cam set for different values of touch probe strokes; electronic tension inverter fixed under the base plate in the area of the touch probe.
- The entire machine is fixed using 4 legs of a 30-mm diameter and a 300-mm length, assembled in the base plate through the screw thread.
- The tugging device composed of table, mobile ensemble and fixed ensemble, which ensures the sliding of the mobile part. The table consists of 5 pieces: piece

12, matrix screw 30x1.5 on a length of 100 mm and disk of 106-mm diameter, threaded, M 106x1.5, 15-mm thick. The piece is fixed to the base plate with the aid of nuts 3 and 4 of M30X1.5, external diameter 70 mm and thickness of 15 mm. The cylindrical surface of the 70-mm diameter is knurled for adherence at the moment of tightening.

Piece 5 is a locknut for locking (stiffening) in the position chosen by the experimenter.

Piece 2 is a special nut with the characteristics shown in the drawing, which ensures the rigid fixation of the sample fastening device to position the table in any area, ensuring perfect axiality for the tugging mechanism to the fixation one.

- The mobile part guiding mechanism in the ensemble of the tugging device is rigidly mounted on column 2 and is composed of two basic pieces: the support for fixation to the column and the nut by which the guiding part of the mobile ensemble from the tugging device is slid. This reaming has a tolerance of 0.15 mm obtained by rectifying pieces entering into contact in order to reduce friction to a minimum.
- The mobile part of the tugging device is designed and built as a flexible axis in a shaft system. It allows an angular displacement that starts in the first joint, which serves to fix the ensemble to the beam in the upper part. This axis ends at the lower part in some “jaws” or “bins” or “mandrels” with aid of which the test sample, of varying size, can be fastened. In order for it not to be crushed, the “mandrel” fastens the sample under the junction areas of dental tissues. After fastening the sample in the mandrel, the entire ensemble is aligned in vertical position, by moving the device into the correct position (perpendicular). After the apparatus has been set, the parameters are chosen: load, stroke, frequency, time etc.
- The mobile part of the compression system differs from that of the tugging system, which is equipped with another range of accessories specific to compression: tips for actuation under different angles (30, 60, 90), tips with wedge profile for shear testing and tips that have the shape of an occlusal molar relief.
- The touch probe as a fundamental piece consists of: fixation column and the touch probe itself, fixed to the base plate. For easy gliding and decreased friction, the column is nut-fastened at the extremities with graphited bronze. The touch probe rod, which slides through the bronze nuts, is rectified and chromated. The contact with the beam is made through a bearing mounted at the upper end of the rod. The lower end which takes over movement from the cam of the motor reducer ensemble is made with a bearing in order to reduce parasite loads and frictions to a minimum.
- The device for fixing weights, balance pan system type, is fixed through a mobile joint to the right extremity of the beam. The Vernier scale slides on the beam and adjusts, with a precision below l00g, the fixed value of the load. After the apparatus has been set and charged with a load, the work regime is selected.

Knowing the load charge, one chooses the duration of loads, the device acting on the sample (tip, 30°, etc), the frequency of impulses, the work system (continuous, cyclic), with constant or variable load, etc. The duration of experiment: if the experiment is aimed at resistance to fatigue or attrition, it can last for tens or hundreds of hours, which means the experiment would have to be repeated for several days. If the experiment is aimed at destroying the sample, a counter will record the programmed number of impulses, or, in the case of crushing, a sensor takes over the information, memorizes it and stops the apparatus.

The machine works at 24V tensions, with a separation transformer. The personnel attending to the machine is protected against electrocution. During the experiment it is not necessary to intervene on the active parts of the machine. Both the weights and the balance pan have a modulated design due to which they are slanted, eliminating the danger of two weights slipping on the contact surface.

Mounting them under the base plate makes access to them more difficult, so accidents cannot occur. The motor ensemble is also placed under the base plate with a fairly limited access, and the transformation ratio of 1:60 makes the cam on reducer output nearly harmless. The limiter mounted in the wiring box interrupts the network on opening the installation. During the testing of hard samples which can be crushed into tiny pieces that can be projected out of control, a transparent protection screen is mounted.

“In vitro” study on the behavior of teeth with endodontic treatment restored with Dentatus devices at oblique compression and traction

The third objective of research is to study “in vitro” the behavior of cast or prefabricated Dentatus CRDs and restored abutment and various plastic obturation materials, at oblique compression and traction. This same thing was done on a lot of 10 remaining monoradicular teeth with cast CRDs.

The literature offers numerous studies in this respect, which are, however, insufficient given the numerous combinations that can be achieved between the restoration material, adhesives, CRDs and fixing materials.

MATERIAL AND METHOD

For this experiment we used the testing machine built at the Polytechnic University of Timişoara (fig. 1). A part of it, through a conic head, exerts vertical and oblique pressures at 30, 60 and 90 degrees, progressively, and the other part exerts tractions, through an elastic nut-type fastening device (fig. 2, 3).

A lot of 18 monoradicular teeth of similar sizes was selected and prepared for aggregation of the Dentatus 4 device according to the techniques described in the last tests (fig. 4).

The coronal abutment was made from:

- indigenous silver and non-gamma 2 amalgam (Blend-a-Med)

- cermet (Miracle-Mix)
- self-polymerizable composite (Culmat)
- glass ionomer cement (Vitremer, 3M)

The devices were cemented using zinc oxyphosphate cement (Dental, Spofa), G.I.C. (Ketac-Cem) and composite cement (Panavia-Ex). Teeth were preserved in formalin and kept in saline solution during experiments.

We chose an attack angle of 30 degrees. The initial weight exerted on samples was 98N and grew progressively to 294N.

We observed the restoration material was fractured, but no device de-cemented or broke.

The results are shown in table 1.

The fourth test consisted of determining the resistance to traction of restorations (table 2).

The most resistant were abutment restorations from Miracle-Mix, then those from Culmat, followed by those from non-gamma 2 amalgam. All abutments were fractured, but the device only de-cemented for those made of Miracle-Mix and composite cement (fig. 7). By comparing traction results with tooth hardness, we observed that the ratio is directly proportional. The harder the reconstruction material, the better it resists traction.

Fig. 2 Testing machine: conical head for oblique compressions

Fig. 3 Testing machine: elastic nut-type head for tractions

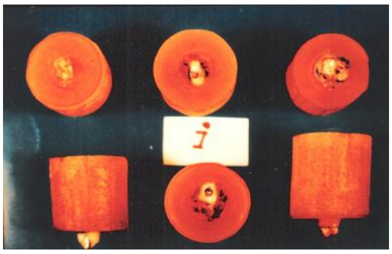

Fig. 4 Lot of teeth with cast and prefabricated (Dentatus) CRDs after strains at oblique compression.

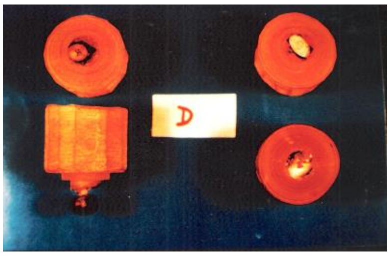

fig. 5 Lot of teeth after strains at oblique compression.

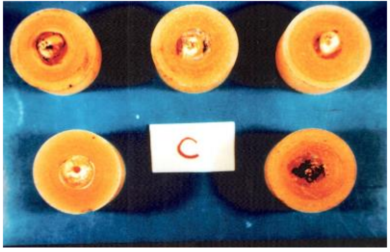

fig. 6. Lot of teeth after traction strains.

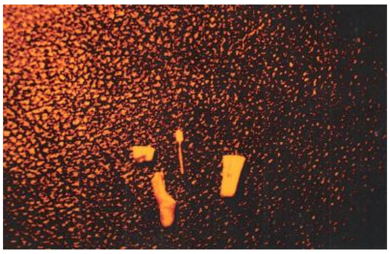

fig. 7 Fractured root after 28 kgf tractions on a Dentatus.

Item	Name of material	Phosphate cement Limited compression (N)	GIC Limited compression (N)	Composite cement Limited compression (N)	Support surface, adhesion, abutment size
1	Non γ2 amalgam	52	62	26	M, M, m

2	Ag amalgam (RO)	24	40	32	m, M, m
3	Culmat	30	20	41	m, m, M
4	Vitremer	21	26	16	m, m, m
5	Miracle Mix	16	20	13	M, m, m

Table 1

Nr		P Cement	I Cement	C cement
		Limited traction (kg.F) Effect on reconstr.	Limited traction (kg.F) Effect on reconstr.	Limited traction (kg.F) Effect on reconstr.
1	Ag non γ2 a	26.72 fractured abutm.	26, 72 fractured abutm.	24.56 fractured abutm.
2	Culmat	23.40 fractured abutm.	38 fractured abutm.	37 fractured abutm.
3	Miracle Mix	36.81 fractured abutm.	37 fractured abutm.	37.38 fractured abutm.

Table 2

We observed that strain in the tooth axis is well supported by natural or restored teeth. Conversely, at oblique compression there are tendencies to destabilize any restoration. In the case of CRDs, the destabilizing phenomenon is materialized in tilting and shearing movement at emergence from the radicular canal, resulting at best in device de-cementing or fracturing. In both cases, the device will negatively strain radicular tissues and can generate dental fissures and fractures.

RESULTS AND CONCLUSIONS

Due to physical and mechanic qualities, cast coronal-radicular reconstructions cannot yet be eliminated from techniques using prefabricated devices.

However, the latter are fast, cheaper and perform relatively well.

Following our study we established the following order of techniques in relation to the amount of positive qualities they possess:

Reconstruction using Dentatus and Culmat is simple, hard, can be polished immediately, with no risk of fracture on the material, is resistant to traction, but not so much to oblique compression.

This technique can be improved by cementing the device with adhesive cement and by improving adhesion between the device, the composite material and dental tissues.

Reconstruction with Dentatus and Miracle-A/Iix has a high level of hardness, high resistance to traction, low resistance to oblique compression, is easily built, can be easily polished immediately after restoration, with no risk of fracture.

The Dentatus can be cemented with the same material. Adhesion among all elements of restoration, as well as between them and dental tissues, is good.

Reconstruction with Dentatus and Ag amalgam has high hardness, is resistant to compression, less so to traction, a cumbersome, time-consuming technique, failure chances are high, it can be fractured on polishing, marginal closure perfected over time.

Dentatus retention can be improved by using adhesive cement.

Reconstruction with Dentatus and Vitremer requires teeth with high remaining coronal walls, has low hardness, inhomogeneous mass.

Adhesion between Dentatus, Vitremer and dentin is good.

The compomer has qualities inferior to all tested materials, therefore it is not recommended for coronal-radicular reconstructions.

Reinforced ionomer and composite cements improve stability and retention of the radicular device in oval roots, or with large destructions due to the carious process, or excessive instrumentation of the canal.

Impressions for these restorations should be made after 7-8 days to stabilize volumetric modifications.

Between working phases, these abutments will be protected by temporary crowns to avoid fluid absorption or dissolution.

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