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The influence of the thickness of a diamond layer on the increase of temperature and the efficacy of drilling while preparing phosphate cement

The way a dentition looks is significant nowadays to judge a person. It results in a great need to replace non-cosmetic fillings (amalgam) with more esthetic ones (e.g. composite fillings). A high abrasiveness of composite materials leads to lowering of the surface of occlusion, which results in the need to replace them with less abrasive materials. The replacement of fillings, especially in the anterior segment, is accompanied by teeth whitening.

In the past, phosphate cement was used as a base material under a permanent filling to treat dental caries. Because of its acidic reaction a protective pulp capping is necessary while inserting it into a tooth. Cement is formed by mixing powdered oxides with acidic fluid. The powder contains zinc oxide mainly, besides magnesium oxide and pigments. The fluid is an aqueous solution of phosphorous acid buffered with aluminium and zinc ions to make sure the setting reaction while mixing takes longer (5). The most significant properties of phosphate cement are: viscosity and a fast setting time, low resistance to mechanical factors (high brittleness), chemical factors(washing out), high porosity (enabling decomposition), high sensitivity to humidity and high acidity of set cement (3).

There is an increase in temperature while preparing phosphate cement. Pulp vitality is in danger when its temperature rises by a critical value of 5°C (1,4). When there is a need to remove cement it is necessary to protect the pulp from the increase of temperature. If the temperature does not rise to the critical value, we can be sure that the pulp-dentinal organ will not reach it, either. Dental pulp necrosis occurs in 1–4% of all the cases while preparing teeth. The main reason for necrosis as well as temporary hypersensitivity is a temperature that rises too high during a procedure (6,7). To avoid overheating of the pulp it is necessary to remember that the technique of drilling should allow for proper pauses, so called "commas". The rule says that we should choose the length of the drilling time and the pause time so as to avoid full growth of pain. The proportion of drilling time to pause time is advised to be 1:2 or 1:1 (6,7).

The facts mentioned above made us analyse the properties of phosphate cement which can influence the whole process of removing it.

The aim of the paper was to show the interdependence between the thickness of a diamond layer and the increase of temperature occurring while preparing phosphate cement as well as the appraisal of the efficacy of drilling.

MATERIAL AND METHODS

The drills of the same company were used in the experiment according to ISO 6360 standards: diamond grains electrolytically inserted in a metal matrix (nickel), a turbine tool (19 mm long), a shape of the head: a ball with a diamond layer, working diameter 2.3 mm (023 according to ISO standards).

The following types of a diamond layer were used: red (smoothing) 30 μm, blue (standard , medium-size) 100 μm, green (rough) 125 μm, black (very rough) 150 μm.

Agatos (a fast-setting cement) was used in the research. It was used according to the producer's recommendations and then installed in a plexy plate (3 mm in diameter and 3 mm thick). The plates with the samples were put to the research kit. The research kit, used to define the increase in temperature while drilling cement, consists of two subassemblies: a mechanical and a measurement part. The mechanical part was constructed in such a way that it was possible to maintain the same repeatable drilling conditions for the tested samples of base cement as well as the tested drills. The research apparatus enabled applying the same conditions while drilling each sample (turbine ends were used). The drilling was performed with the drill of an even load strength and with an unchanging frequency of drilling (2 seconds of work and 2 seconds of pause). The mechanical part consists of an arm with a cam and a drill fastened to it.

The cam is replaceable and is driven by an electric engine with the option to change the rotation speed. We can adjust the frequency of work by installing a proper cam and applying a proper rotation speed of the engine according to the measurement theories. A weight on a crane is mounted to the working side of the arm. The regulation of a load strength of the drill on an examined sample is possible because of the changed position of the weight. The depth of preparation can also be regulated. The use of a special table for material samples that moves both ways and therefore enables putting a temperature sensor in any position makes both functions mentioned above possible. The measurement part consists of a temperature sensor and the scales. The temperature sensor is a thermocouple (TP-201K-1b-100-1) which means a sensor of a single-coat thermocouple (NiCr-NiA1 (K)) 0.5 mm in diameter, with a measuring junction galvanically isolated from the coat. of the length of a thermocouple L=100 mm and with a one-meter compensating lead. The sensor cooperates with Tik Corp, an appliance used to record the temperature digitally. The information on the change of temperature can be registered by a computer program. The second component of the measurement part is the scales with the table fixed to it. The table is used to put material samples on. This kind of a kit enables a running control of a load strength of the drill.

The increase in temperature was registered in relation to time. Forty repetitions were performed for each drill (three drills with each layer).The efficacy of drilling was defined simultaneously with preparing phosphate cement. The thickness of each sample was measured with "Schnelltester", a thickness meter. After drilling the measurement was repeated. The size of a cement cavity showed how efficient the drill was.

RESULTS

It was proved that the speed of the increase in temperature while drilling cement depends on a kind of a diamond layer that was used. The slowest increase of temperature was recorded accordingly with a 30 μm layer (red), 100 μm (blue), 125 μm (green), and with a 150 μm (black one).

The following results were achieved in the part of the research aimed at defining the efficacy of drilling phosphate cement: a cement cavity (2.25 mm thick) for a black layer, a cement cavity (1.05 mm thick) for a green layer, a cement cavity (0.82 mm thick) for a blue layer, a cement cavity (0.68 mm thick) for a red layer.

CONCLUSION

Concerning the speed of the temperature increase, the drills of a 30 μm layer (red) appear to have the most advantageous parameters. The drills of a 150 μm layer (black) are the most effective. Taking into account the speed of the temperature increase and the efficacy of drilling, the drills of a 100 μm layer (blue) and a 125 μm layer (green) are the best.

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SUMMARY

The aim of the paper was to show the interdependence between the thickness of a diamond layer and the increase of temperature occurring while preparing phosphate cement as well as the appraisal of the efficacy of drilling. The drills of the same company were used in the experiment according to ISO 6360 standards: red (smoothing), blue (standard, medium size), green (rough), black (very rough). Agatos (a fast-setting cement) was used in the research. The research kit was used which made possible to maintain the same repeatable drilling conditions of each sample of the cement. The increase of temperature was registered by the NiCr-NiAl thermocouple. It was proved that the fastest increase of temperature while drilling cement was recorded with drills of a very rough layer. The drills of a very rough layer are also the most effective.

Wpływ grubości nasypu diamentowego na wzrost temperatury oraz efektywność nawiercania podczas opracowywania cementu fosforanowego

Celem pracy było wykazanie zależności między grubością nasypu diamentowego wiertła a wzrostem temperatury, powstającym podczas opracowywania cementu fosforanowego oraz ocena efektywności nawiercania. Do doświadczeń użyto wierteł jednej firmy zgodnie z normami ISO 6360, o jednakowej średnicy i kształcie części pracującej oraz następujących nasypach diamentowych: czerwony (wygładzający), niebieski (standardowy, średni), zielony (zgrubny), czarny (bardzo zgrubny). Badaniu poddano cement fosforanowy szybkowiążący Agatos. Wykorzystano zestaw badawczy, który ujednolicał warunki nawiercania każdej z próbek cementu fosforanowego. Rejestrowano przyrost temperatury w czasie za pomocą termopary NiCr-NiAl. Podczas przeprowadzanych badań największy przyrost temperatury występował przy użyciu wierteł o bardzo zgrubnym nasypie, największa efektywność wystąpiła także przy użyciu wierteł o bardzo zgrubnym nasypie.