

This study deals with the evaluation of endodontic treatment using calcium hydroxide materials in immature permanent teeth that have sustained traumas, especially after severe periodontal tissue injuries.

- The aim of this work was:

- a. to analyze the factors that contribute to occurrence of post-traumatic complications, especially after avulsion injuries in immature permanent teeth ,
- b. to investigate the effectiveness of endodontic therapy of these complications with the use of calcium hydroxide materials in immature permanent teeth,
- c. to evaluate various calcium hydroxide materials,
- d. to compare our results with other studies in literature concerning calcium hydroxide properties in cases that it is used as an intra-canal medicament.

- The pre-clinical and clinical parts of this thesis are divided in 3 parts:

1. Evaluation of primary schools teachers` knowledge on providing first aid in cases of tooth avulsion injuries: immediate and proper first aid and fast transfer of children to dental practitioner are determining factors for prognosis of the injured tooth and for future occurrence of post-traumatic complications. 300 teachers were asked to fill questionnaires about avulsion of permanent teeth. 69 % of the respondents had never been informed about providing first aid in dental trauma situations, 34 % had never heard the term “avulsion” and 81 % would keep the avulsed tooth in a dry handkerchief until the transfer to dental practitioner. These results proved inadequate knowledge of teachers in providing first aid in dental trauma situations, although schools are frequent places that these injuries occur. This fact worsens the outcome of dental treatment and the prognosis of injured teeth.

2. Retrospective analysis of 90 avulsed teeth in 57 children: this study was concentrated mostly in type of treatment (replantation or not), time interval between injury and dental treatment, storage medium, occurrence of post-traumatic complications and endodontic treatment in teeth with open root apices. Only 27 teeth (30 %) were replanted; 12 were with unfinished root development. 10 out of 12 teeth with open root apices were endodontically treated with calcium hydroxide (apexification), since revascularisation of the pulp was not noticed and in 8 of them apical barrier was formed. In two cases, pulp revascularisation occurred and subsequent pulp canal obliteration was investigated some time after the injury. Two replanted teeth with unfinished root development had to be extracted because of advanced infection related root resorption. Prolonged extra-oral period or storage of the avulsed tooth in improper storage medium until tooth replantation influence the outcome of treatment and increase the risk for occurrence of post-traumatic complications.

3. Endodontic intervention in treatment of post-traumatic complications in immature teeth: the records in documentations of a group of 178 patients with 383 teeth, who were treated for dental traumas in Dentistry department of Faculty of Medicine and Faculty hospital in Pilsen, were analyzed, concentrating mostly in occurrence of post-traumatic complications in lateral luxation injuries and in complicated and uncomplicated crown fractures in immature, permanent teeth. 156 out of 383 injured teeth were immature teeth.

In 70 lateral luxations and subluxations in immature teeth, root canal obliteration occurred in 19 cases, pulp necrosis in 9 cases and inflammatory root resorption in 4 cases. In 50 uncomplicated crown fractures in immature teeth, the most frequent post-traumatic complication occurring was pulp necrosis (7 cases, 14 %) which was always treated endodontically. All teeth with pulp necrosis and infection related root resorption, were treated with calcium hydroxide. In 11 out of 12 teeth that had necrotic pulp in the above injuries, calcium hydroxide showed to have good results since resulted in apexification. One tooth had to be extracted because even after filling of root canal with calcium hydroxide paste, infection related root resorption progressed.

- The experimental part of the thesis aimed to bring up new information concerning the effect of calcium hydroxide, when it is used as an intra-canal medicament for short-term and when it is used for long-term, especially in cases of apexification of immature teeth. Various calcium hydroxide materials that are used in Dentistry department of Faculty hospital in Pilsen were used:

- "Calxyd" (Spofa Dental, CZ), composition: Ca(OH)<sub>2</sub>, glycerine, distilled water
- "Calxyl" (OCO Präparate, Germany)
  - a) red, composition: Ca(OH)<sub>2</sub>, distilled water
  - b) blue, composition: Ca(OH)<sub>2</sub>, distilled water, Barium Sulphate
- "Dentbalzam" (Spofa dental, CZ), composition: Ca(OH)<sub>2</sub>, distilled water
- "Calcium hydroxide PLUS points" (Roeko, Germany), composition: 52 % Ca(OH)<sub>2</sub>, 42 % gutapercha, sodium chloride, dyes.

The experimental part of this study was divided in 5 parts:

1. Calcium hydroxide in endodontics – measuring of pH of various materials in vitro:

The aim of this experiment was to measure the pH and to discover if added substances influence the pH values of the above materials.

For that reason, equal weight quantities of each material were applied in equal volume of distilled water in closed plastic tubes and in 10 min., in 30 min. and in 7 days the pH of distilled water was measured using WTW Microprocessor pH meter pH 537.

It was measured that all materials in paste form had high pH values, ranging between 11.65 and 11.82. The pH of calcium points was almost neutral (6.73), even after 1 week.

## 2. Diffusion of calcium ions into saline solution of various materials in vitro:

For this experiment, the same materials were used. The aim of this experimental study was to investigate the ability of penetration of calcium ions of the used materials with calcium hydroxide through apical foramen in vitro; subsequently to measure the concentration of calcium ions and calculate and compare the pH of these materials.

For that reason each from the above materials was applied in a small plastic pipette with an opening of 0,5 mm, simulating a single root tooth. These pipettes were then placed in small, plastic, closed tubes which were containing saline solution. With the help of WTW Microprocessor pH meter pH 537 the concentration of calcium ions of saline solution was measured repeatedly. These measurements revealed that concentration of calcium ions in saline solution where pipettes containing materials in paste form was higher than in pipettes with calcium points.

## 3. Calcium and hydroxyl ion diffusion through dentin - comparison study of various materials:

For this experiment, the same materials were used. The aim of this study was to find out the diffusion ability of calcium and hydroxyl ions from root canal to periradicular environment through dentin tubules in cases of exposed root dentin, after endodontic use of calcium hydroxide and subsequently to compare the concentration of calcium ions and changes of pH in the extraradicular environment after the use of various materials with calcium hydroxide.

25 intact premolars extracted for orthodontic reasons were used and in each tooth at middle root third, a cavity was prepared simulating root resorption. The teeth were treated endodontically, instrumented in the same conditions and the same way and in every 5 teeth the same, from the above, material was applied. The trepanation cavity was filled with glass ionomer cement and the apical foramen was covered with the same material.

Two control teeth with their root canals filled with paper points were prepared the same way. The teeth were then placed into plastic tubes containing saline solution. Only the roots of the teeth were inserted into the solution. At specific time intervals the teeth were placed into reserve plastic tubes and in the original tubes the concentration of calcium ions in the saline

solution was measured. After measurement, the teeth were placed back into the original tubes. The measurements were repeated every hour for the first 12 hours and later and later, once every 24 hours for 21 days.

The results revealed that hydroxyl and calcium ions diffuse through dentin tubules into saline solution. The speed of diffusion depends on the contents and on the consistency of each calcium hydroxide preparation. Higher calcium concentration and higher pH in saline solution were measured in cases of materials in paste form.

#### 4. Measurement of dentin hardness in teeth with long-term root canal filling with calcium hydroxide:

The sample teeth of the previous experimental study were used. These teeth had been stored in saline solution, in closed glass tubes, in room temperature for 1 year. The teeth were fixated with ethanol and embedded in EPON using standard procedures. Subsequently, the teeth were placed into a thermostat and then were stored into room temperature conditions. For grinding of samples the machine “HK 350 disc grinder” was used. At the beginning, rough abrasive grinding was performed. The samples were held against the grinding disc, until half of the tooth (longitudinally) was removed, so that the whole pulp cavity was exposed. After rough grinding, plane grinding was performed and then fine grinding. The cooling and lubricant agent which was used in all phases of grinding was distilled water. Final polishing was achieved by Labopol 5 polishing machine. Polishing was performed, in order to produce smooth tooth surfaces, important for nanoindentation technique (dentin hardness measurement).

The root-dentin micro-hardness of 2 specimens of each material and 5 control teeth was measured, using nanoindentation tests with Nano Indenter XP. These measurements were realized towards the whole length of dentin of the root, at the side where the cavity had been prepared. A total of 50 indents were produced, in distance of 200  $\mu\text{m}$  from each other.

These 50 measurements of dentin hardness of each sample were statistically analyzed and evaluated and the mean values of dentin hardness of each specimen and control teeth were produced and compared with each other.

Results revealed that teeth that had been filled with calcium hydroxide presented with higher values of dentin hardness than control teeth, proving that long-term use of calcium hydroxide (eg. in cases of apexification, or treatment of chronic periodontitis) influences root dentin hardness of the teeth.

#### 5. Histological evaluation of dentin hypercalcification after long-term root canal filling with calcium hydroxide:

We performed a microscopic study of root dentin. The aim of this study was to observe in Scanning Electron Microscope (SEM) the root dentin after long-term use of calcium hydroxide. We compared teeth, filled with calcium hydroxide and teeth without any root canal filling. Furthermore, with the help of SEM, we compared the percentage weight of calcium in areas of root dentin between teeth that had been filled with calcium hydroxide and teeth without any endodontic filling. It was observed that teeth that had been previously treated with long-term use of calcium hydroxide had hypercalcified areas at their root dentin, dentin tubules contained particles of calcium hydroxide paste and in intertubular dentin calcium crystals were identified. In addition, the percentage weight of calcium in root dentin was measured higher in teeth that had been filled with calcium hydroxide than the control teeth that had been used in this experiment. The above lead us to the conclusion that long-term use of calcium hydroxide may lead to structural changes and hypercalcification of root dentin.