Long-term Outcomes of Full Pulpotomy in Permanent Molars for Patients Treated in a Single, Short Session under Special Conditions

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LONG TERM OUTCOMES OF FULL PULPOTOMY IN PERMANENT MOLARS
FOR PATIENTS REQUIRING ENDODONTIC TREATMENT TREATED IN A
SINGLE, SHORT SESSION: A RETROSPECTIVE STUDY UNDER SPECIAL
CONDITIONS

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DECLARATIONS OF INTEREST: The authors deny any conflicts of interest related to this study.
ABSTRACT

OBJECTIVES: Endodontic procedures for patients requiring treatment in a single, short session need to be validated. This study aimed at evaluating the long-term outcome of full pulpotomy in permanent molars performed with reinforced zinc oxide-eugenol cement (Intermediate Restorative Material (IRM®)), immediately restored using stainless steel crowns under general anaesthesia (GA).

MATERIALS AND METHODS: The absence of clinical signs and symptoms and the evolution of the Peri-Apical Index between the treatment date (T0) and the longest follow-up time (T1) were used to grade pulpotomy outcome as “effective”, “uncertain” or “ineffective”. Impact of different criteria on pulpotomy outcome was tested (aetiology of lesion, tooth maturity, endodontic difficulty related to coronal shape and root canal shape, and endodontic difficulty related to radiographic root canal appearance).

RESULTS: Among the 608 teeth (338 patients), treated in a single session with IRM® full pulpotomy and stainless steel preformed crowns, 263 (143 patients) were evaluated after a median follow-up period of 24 months. Overall, 89% of pulpotomies were effective, 7.6% were of uncertain outcome and 3.4% were ineffective. No tested criteria influenced the rate of effectiveness.

CONCLUSIONS: Long-term outcomes of IRM® pulpotomy are similar to those of calcium silicate based-cement pulpotomy observed in the literature. This procedure should not be restricted to patients treated under GA however, as it is relevant for all special conditions that impose the provision of endodontic treatment in a single, short session, such as dental care emergencies during humanitarian crises or pandemic periods.
KEYWORDS

Full pulpotomy; Permanent molar; General anaesthesia; Preformed crowns; Follow-up study;

Single session
INTRODUCTION

For the purposes of this article, ‘special conditions’ is a term characterizing a medical, social or environmental context that imposes restrictions on the provision of conventional dental treatment. These restrictions may include limited intervention time, need for rehabilitation in a single, short session, particular ergonomic conditions, difficulty in reaching a precise diagnosis, availability of low cost materials only, and need for easily handled materials. Such special conditions are encountered during pandemic periods due to the need to limit high-risk contamination by saliva, blood, mucosal secretions and physical contact; during dental care under general anaesthesia (GA); and during humanitarian dental interventions. Reversible and irreversible pulpitis due to deep carious lesions or injury are the most common complaint reported in these situations (1). In order to avoid extractions, endodontic procedures should be adapted to the context of the special conditions, whilst aiming to obtain the same outcome as conventional academic procedures, i.e. maintenance of an asymptomatic and functional tooth in the mouth (2).

In past years, convergent results from the literature suggest that permanent vital teeth with pulpitis (3) may be treated using full pulpotomy. A recent systematic review reported a clinical success rate of pulpotomy performed on permanent teeth with irreversible pulpitis of 93.97%, and a radiological success rate of 88.39% after 36 months follow-up (3). Several studies have shown similar success rates for full pulpotomy compared to root canal treatment (RCT) (3,4). It might be expected that full pulpotomy will become the endodontic treatment of choice for affected teeth with a vital pulp, instead of RCT. This may be particularly true for difficult endodontic cases (5) and when treatment is undertaken in special conditions limiting the operatory time and subsequent intervention. Patients consulting dental services during pandemic periods, those treated under GA, and those treated during humanitarian crises share the same special conditions for treating vital teeth with deep carious lesions.
Performing endodontic under special conditions is a challenge as RCT is time-consuming and requires advanced technology (6). These conditions are neglected in the international guidelines. Local protocols established in these contexts indicate extraction, abstinence and/or prescription instead of endodontic treatment. Consequently, being treated under special conditions implies degraded treatment outcomes with extractions being preferred to minimally invasive endodontics. Ethical issues impose however that patients receive equitable quality of care, and equitable treatment outcomes, whether treated conventionally or under certain constraints (7). In this context, it is legitimate to investigate whether full pulpotomy can be indicated instead of RCT. Answering this question implies reviewing the literature to define which procedures and materials could be used for full pulpotomy and coronal restoration in a single session, and then verifying the outcomes of these adapted procedures by clinical trial. Data from dental treatment under GA might be considered as a reference for full pulpotomy under special conditions, potentially offering an opportunity to evaluate this conservative solution for treating patients during pandemic periods or humanitarian crises.

Literature reviews on materials for full pulpotomy report radicular pulp capping with Calcium Hydroxide (CaOH$_2$), CaOH$_2$ covered with Zinc Oxide Eugenol cement (ZOE) or reinforced zinc oxide-eugenol cement IRM® (Intermediate Restorative Material), ZOE, Calcium-Enriched Mixture (CEM), Mineral Trioxide Aggregate (MTA) or Biodentine™ (8,9). It has previously been suggested that the removal of the most inflamed part of the pulp followed by cavity sealing to avoid reinfection, is a reliable means to obtain pulp sedation (10). Overall, there is agreement that calcium silicate cements, such as MTA, CEM and Biodentine™, are pulpal regenerative materials that can result in both pulp healing and clinical success. However, positive clinical results have also been reported with CaOH$_2$ (11) or CaOH$_2$ covered with ZOE (12) or IRM® (13), despite the lack of regular tertiary dentinogenesis induction. Thus procedural arguments, instead of biological ones, may be considered when
proposing materials for radicular pulp capping under special conditions. The chosen pulp
capping material should be easy to handle, have a fast setting time and be compatible with
immediate coronal restoration. The setting time of MTA is long, over two hours, leading to a
delay in the permanent restoration and increasing the risk of immediate post-operative
contamination. Of the these materials reported for pulpotomy in permanent teeth, only
Biodentine™ and IRM® allow the tooth to be restored immediately. The setting times of
Biodentine®, MTA Angelus® or MM-MTA® are much longer than that of IRM® and their
costs are much higher. All these considerations tend to indicate IRM® as an appropriate pulp
capping material for full pulpotomy performed under special conditions. However, IRM® is
not currently considered to be a pulp capping material except for deciduous teeth (14) and
there is a need to assess the long-term outcome of pulpotomies undertaken using this material.

The decision to use stainless steel crowns for the coronal restoration of teeth with deep
carious lesions following pulpotomy under GA was also based on previous studies. Survival
rates of teeth with carious cavities on more than three surfaces have been shown to be higher
when restored with full or partial crowns rather than with composite restorations (15). Teeth
being restored with composite (16,17) had worse fracture resistance and marginal integrity,
increased cervical marginal micro-leakage, more surface roughness, postoperative sensitivity
and soft-tissue irritation than those restored with indirect full or partial crowns. Indirect
restoration is not feasible under special conditions, direct bonded restorations are time
consuming and incompatible with IRM, amalgam restorations are generally to be avoided for
ecological reasons. The use of pulpotomy with IRM® followed by the immediate placement
of a stainless steel crown could thus be a conceivable alternative procedure for the treatment
of vital teeth under special conditions (18,19).

This study aims to assess the long-term outcome of pulpotomies performed with IRM® on
permanent molars and immediately restored using stainless steel crowns under GA.
MATERIALS AND METHODS

Type of study
This retrospective study was approved by the local ethical committee (CE-CIC-GREN-5044-11/17) and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Data collection
The study population consisted of all patients from the special care unit of the Dental University Hospital of Clermont-Ferrand, treated under GA between November 2008 and July 2017. Local protocols impose a conservative full-mouth rehabilitation approach with as few extractions as possible. Indications included patients presenting anxiety disorders and high levels of carious disease, medically-compromised patients, patients with disability (physical, cognitive or mental) and patients presenting with a severe gag reflex. For all patients, a full record is kept of the dental status and diagnoses at the start of the intervention, and of the treatment provided during that session. Patients were excluded if the treatment did not include at least one permanent molar treated by full pulpotomy and stainless steel crown placement. The beginning of the follow-up period (T0) was defined as the date at which the pulpotomy was performed under GA. The immediate post-operative radiograph was collected.

After GA, patients are routinely scheduled for a one-month post-operative appointment. They are then free to come back to the hospital for regular annual check-ups if they wish. Clinical and radiographic evaluations were undertaken at each check-up appointment. Regular check-ups were undertaken in the dental surgery with or without conscious sedation, or under subsequent GA depending on the level of patient cooperation. No systematic recall of patients was carried out, except for the one-month post-operative appointment. For each patient, the
radiological and clinical data recorded at the longest follow-up period (T1) were retained to assess pulpotomy outcome.

**Pulpal status**

Performing all diagnostic tests pre-operatively was not systematically possible due to medical, physical, cognitive or mental conditions of the patients. Pulpal status was evaluated during the intervention under GA, and the tooth was categorized as either vital or non-vital according to clinical and radiological criteria. During the clinical examination, the absence of a sinus tract or swelling were verified. Radiographically, peri-apical health was determined on retro-alveolar radiography using the Peri-Apical Index (PAI), described by Orstavik et al. in 1986 (20). Pulpotomies were performed on teeth with a PAI of 1, 2 or 3. Pulp vitality was confirmed per-operatively by presence of bleeding in the pulp chamber and from the canal orifices. Conventional root canal treatment was performed for non-vital teeth and these were not included in the study.

**Procedure for pulpotomy**

After rubber dam placement, carious tissue was removed under irrigation with a round tungsten carbide bur in a slow-speed hand-piece. Once the pulp chamber was opened, constant irrigation with 2.5% hypochloride solution was used for each further step. Shaping of the access cavity was undertaken with a Zekrya bur in a high-speed hand-piece. Preparation of the canal orifices was undertaken with a no. 3 or 4-sized Gates Glidden bur in a slow-speed hand-piece. Bleeding had to stop within 6 minutes. After final hypochloride irrigation and drying, pulp capping was performed by placing zinc oxide-eugenol cement (IRM®) into the access cavity and all canal orifices. The definitive restoration was undertaken immediately after the pulpotomy procedure, using stainless steel preformed crowns sealed with glass ionomer cement (GIC).
Outcome evaluation criteria

Outcome evaluation included a combination of clinical and radiographic examination (Table 1) (21). Radiographically, the evolution of PAI (20) was assessed between T0 (post-operative radiograph taken immediately following treatment) and T1 (radiograph taken during the latest check-up appointment). For a tooth with multiple root canals, the root with the highest PAI is taken into account. For immature teeth, further physiological root growth was verified between T0 and T1.

Clinical assessment was undertaken by the patient’s usual practitioner at a regular check-up appointment. Data regarding presence of pain, sinus tract, or swelling were recorded in the patient’s medical file. Due to the ethical frame of this observational study, it was not possible to blind the assessors to the collection of clinical data. However, blind assessment was respected for radiological assessments. PAI scores at T0 and T1 were assessed using the immediate postoperative and long-term follow-up radiographs. The calibrated investigators scored the PAI for each tooth independently. Preoperative radiographs were not considered for outcome assessment in order to blind assessors between T0 and T1 images.

For the evaluation of radiological criteria, all radiographs collected at T0 and T1 were proposed in a random order to be interpreted by two calibrated investigators. If there was a disagreement, a consensual decision was made between both readers and a third calibrated investigator. For calibration, both investigators were trained to interpret PAI scores with a test and retest 15 days apart on 100 X-rays illustrating the five score categories. The intra-class correlation coefficient (ICC) for inter-rater assessment was 0.95 (p<0.001) for the test phase and 0.93 (p<0.001) for the retest at 15 days. Intra-rater validity was 0.87 (p<0.001) for the first expert and 0.90 (p<0.001) for the second expert. The first examiner’s reliability was 0.87 (p<0.001) relative to the expert panel on the test and 0.89 (p<0.001) on the retest at 15 days.
and for the second examiner, the reliability relative to the expert panel was 0.86 (p<0.001) on the test and 0.88 (p<0.001) on the retest.

176  **Factors potentially affecting treatment outcomes**

177  **Aetiology**

178  The dental pathology or indication for endodontic treatment were grouped into four categories: carious disease, molar-incisor hypomineralisation, bruxism, and endodontic treatment in preparation of prosthetic rehabilitation.

179  **Tooth maturity**

180  Teeth were dichotomized into two categories with regards apical growth (mature/immature teeth) (22).

181  **Potential difficulty of endodontic treatment**

182  Evaluation of the potential difficulty of RCT was performed using the American Association of Endodontists form (23,24). Only three criteria were applicable for pulpotomies: coronal shape, root canal shape, and root canal radiographic appearance.

183  **Statistical analysis**

184  Descriptive analysis was performed using Excel and the statistics were undertaken using IBM SPSS Statistics version 25 (Statistical Package for the Social Sciences). Student’s t-tests were used to compare the whole group to the follow-up group with respect to age, average duration of the intervention under GA, and average number of teeth treated under GA. Pearson chi-squared tests were used to compare the whole group to the follow-up group with regards sex, patient typology, data on the type of treated teeth and also to analyse the impact of aetiology, tooth maturity and endodontic difficulty criteria on pulpotomy outcomes.
RESULTS

Participants
The distribution of included teeth (patients) is presented in Figure 1. The whole study group consisted of 338 patients (age range: 7-93 years old; of which 96 were <16 years-old) presenting 608 permanent molars treated with full IRM® pulpotomy and immediately restored with stainless steel crowns.

The follow-up group consisted of 143 patients (age range: 9-64 years old; of which 21 were <16 years-old), presenting 263 treated teeth, who attended a follow-up check-up during which a complete clinical and radiological examination could be performed. The patient follow-up rate was 42.3%. The average follow-up time was 29.9 ± 26.6 months (min = 1, max = 88). The median follow-up time was 24 months. Comparisons between whole and follow-up groups are reported in Table 2 in terms of patients and in Table 3 in terms of teeth.

Follow-up evaluation
Of the 263 evaluated treatments, 234 (89%) were effective, 20 (7.6%) were of uncertain outcome and 9 (3.4%) were ineffective. The rate of effectiveness was 91.7% within 24 months and 86.2% after a follow up period of over 24 months. The distribution of the treatments’ outcome is presented in Table 4. Of the factors tested, no criteria statistically influenced the outcome (Pearson Chi square test, NS).

DISCUSSION
Treating vital teeth using IRM® full pulpotomy and stainless steel crown placement in a single session is effective in the long term. This study was conducted in patients treated under
GA, but its findings concern other special conditions in which patients require treatment in a single, short session. In such special conditions, this procedure allows vital teeth to be managed with a long-term goal, avoiding both extraction and the need for a second appointment. Time constraints and one-off service access are special conditions that often exclude conventional endodontic procedures, particularly if several teeth need to be treated.

Pulpotomy and immediate stainless steel crown placement in vital permanent teeth are adapted procedures that should be considered as validated alternatives to conventional “academic” procedures in such conditions. This study demonstrated that these alternative procedures attain the outcomes of academic treatments i.e. maintenance of an asymptomatic and functional tooth in the mouth. Moreover, the opportunity remains to replace stainless steel crowns with conventional crowns at a later stage, when the causes determining the special conditions relent. In terms of public health, this implies that there is no loss of equity in treatment outcomes as patients retain all the benefits of preserving their teeth.

Beside the public health implications, it is of interest to discuss the results of this study in light of previous studies on full pulpotomy. Based on clinical and radiological criteria, this study reports unexpectedly positive results from full pulpotomy with IRM®. A previous study reported strong evidence for the use of MTA, CEM or Biodentine™ for pulp capping (21). Differences between criteria used to evaluate the success of pulpotomy could explain this situation. Some authors focus on the biological effect of the pulpotomy material on the pulp and evaluate the development of a dentinal bridge as a criterion of success (25–27). However, the radiological evaluation of the development of a dentinal bridge is not reliable and even if it is detected, neither the quality of the bridge nor the pulpal status under the bridge can be tested (21). Moreover, a dentinal bridge is not always created under calcium silicate based-cements, such as MTA and Biodentine™ (28). Such criteria assess the biological impact of the material on pulpal tissues, considered as a sign for biocompatibility of material, rather
than the effectiveness of the pulpotomy. Other authors consider preservation of a functional
tooth as a successful outcome (21). In this case, as for conventional RCT, evaluation criteria
combine both a clinical and a radiological examination. The state of the radicular pulp cannot
be objectively assessed. Indeed, vitality tests do not faithfully reflect the histological state of
pulpal tissues (29–31). Moreover, pulp vitality tests are not reliable once a material has been
placed over the pulp canal orifices and it may be difficult to evaluate pulp vitality (21). In the
absence of bacterial contamination, asymptomatic irreversible pulpitis and necrobiosis would
not evolve toward further disease (32). The efficiency of pulpotomy is thus assessed clinically
and radiographically with the evaluation of the absence of signs of failure. Clinically, failure
is expressed by signs and symptoms of acute disease (spontaneous pain, pain on percussion,
pain on apical palpation, swelling) or chronic disease (sinus tract). Radiologically, failure is
expressed by the development of a periapical lesion, or with an increase in size of a pre-
existing periapical lesion. In this study, no apical disease was recorded for 89% of cases and
radiological uncertainty was recorded for 7.6%. The absence of evolution of a pre-existing
periapical lesion suggests that the treatment outcome is uncertain and needs further follow-up
(24) (21).

The composition of the pulp capping material is not the main factor for the successful
outcome of pulpotomy. The key concept for effective pulpotomy is the prevention of bacterial
infection (21). During the current study, initial vital pulp status was verified by the absence of
clinical and radiological signs of infection and by the presence of bleeding in the pulp
chamber and all canal orifices. Aseptic conditions were maintained during all pulpotomy
procedures as rubber dam was systematically placed before removal of carious tissue and
discharging was ensured using sodium hypochlorite irrigation. Placement of IRM® as a pulp
capping material allowed immediate seal of the radicular pulp segments. Finally, an
immediate hermetic coronal restoration was guaranteed by the placement of stainless steel
crowns, providing long-term sealing of the pulpotomy. The combination of all these elements, and particularly the immediate hermetic coronal restoration (8, 27, 28, 33–35), are probably the factors that best explain the high level of effectiveness for pulpotomy reported here. The peripheral seal achieved with glass ionomer cement (GIC) and stainless steel crowns is efficient enough to avoid postoperative contamination, GIC dissolution being limited under the crown. It has been reported that the survival of posterior permanent teeth restored with stainless steel crowns is 79.2% after 10 years and this therefore represents a viable treatment choice for severely carious or fractured posterior permanent teeth (18). However, serious concerns are raised regarding the ability of preformed stainless steel crowns to satisfy the same specifications as those required from a conventional crown. The quality of the cervical margin of the coronal restoration could affect the long-term outcome of pulpal therapy. Indeed, high adaptation of the cervical limits might induce coronal contamination and radicular contamination is a risk if the margin is too low. Additional studies are needed to determine the tooth survival rate and the degree of periodontal morbidity induced by preformed crowns.

CONCLUSION

The treatment of vital teeth under special conditions should be cause for reflection in endodontic communities. Full pulpotomy with IRM® followed by immediate placement of a stainless steel crown cemented with GIC is a validated alternative procedure to conventional RCT and offers a satisfactory treatment outcome when performed under GA. This procedure should not be restricted to patients treated under GA however, as it is relevant for all special conditions that impose the provision of endodontic treatment in a single, short session, such as dental care emergencies during humanitarian crises or pandemic periods.
ACKNOWLEDGMENTS

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REFERENCES


33 Solomon RV, Faizuddin U, Karunakar P, Deepthi Sarvani G, Sree Soumya S. Coronal Pulpotomy Technique Analysis as an Alternative to Pulpectomy for Preserving the Tooth Vitality, in the Context of Tissue Regeneration: A Correlated Clinical Study across 4
FIGURE CAPTIONS

Figure 1: Distribution of included teeth (patients) over the duration of follow-up for the whole cohort.
Table 1: Clinical and radiological criteria used to assess pulpotomy outcome (21). (The condition for ineffective pulpotomy with PAI (T0) ≥ 3 and PAI (T1) > 3 could be checked only for teeth with PAI (T0) = 3, as PAI (T0) > 3 were not included in the cohort).

<table>
<thead>
<tr>
<th>Clinical examination</th>
<th>Radiographic evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective pulpotomy</td>
<td>Absence of signs and symptoms after pulpotomy</td>
</tr>
<tr>
<td></td>
<td>- PAI (T0) and PAI (T1) = 1</td>
</tr>
<tr>
<td></td>
<td>- or PAI (T0) = 2 and PAI (T1) ≤ 2</td>
</tr>
<tr>
<td></td>
<td>- or PAI (T0) ≥ 3 and PAI (T1) ≤ 2</td>
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<tr>
<td></td>
<td>- and lack of radicular lacunae</td>
</tr>
<tr>
<td></td>
<td>- for immature teeth: further physiological root growth</td>
</tr>
<tr>
<td>Uncertain pulpotomy</td>
<td>Absence of signs and symptoms after pulpotomy</td>
</tr>
<tr>
<td></td>
<td>- PAI (T0) = 1 and PAI (T1) = 2</td>
</tr>
<tr>
<td></td>
<td>- or PAI (T0) and PAI (T1) = 3</td>
</tr>
<tr>
<td></td>
<td>- and lack of radicular lacunae</td>
</tr>
<tr>
<td>Ineffective pulpotomy</td>
<td>Presence of signs and symptoms after pulpotomy</td>
</tr>
<tr>
<td></td>
<td>- PAI (T0) = 1 or 2 and PAI (T1) ≥ 3</td>
</tr>
<tr>
<td></td>
<td>- or PAI (T0) ≥ 3 and PAI (T1) &gt; 3</td>
</tr>
<tr>
<td></td>
<td>- and/or presence of radicular lacunae</td>
</tr>
<tr>
<td></td>
<td>- for immature teeth: no further physiological root growth</td>
</tr>
</tbody>
</table>
Table 2: Comparison between the whole group and the follow-up group in term of patient data.

<table>
<thead>
<tr>
<th></th>
<th>Whole group of patients (n=338)</th>
<th>Follow-up group of patients (n=143)</th>
<th>Pearson Chi Square Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (% (n))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>52.7% (178)</td>
<td>53.1% (76)</td>
<td>ns</td>
</tr>
<tr>
<td>Women</td>
<td>47.3% (160)</td>
<td>46.9% (67)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean ±SD</td>
<td>27.1 ± 14.5</td>
<td>29.9 ± 12.7</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Patient typology (% (n))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety disorder / multiple caries</td>
<td>55% (186)</td>
<td>58.7% (84)</td>
<td>ns</td>
</tr>
<tr>
<td>Medically compromised</td>
<td>21.6% (73)</td>
<td>21.0% (30)</td>
<td>ns</td>
</tr>
<tr>
<td>Disability</td>
<td>20.1% (68)</td>
<td>19.6% (28)</td>
<td>ns</td>
</tr>
<tr>
<td>Gag reflex</td>
<td>1.2% (4)</td>
<td>0</td>
<td>ns</td>
</tr>
<tr>
<td>Missing data</td>
<td>2.1% (7)</td>
<td>0.7% (1)</td>
<td></td>
</tr>
<tr>
<td>Duration of GA intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean ± ET (minutes)</td>
<td>109.7 ± 33.1</td>
<td>121.0 ± 31.3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Missing data (n)</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Number of teeth treated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean ± SD</td>
<td>12.9 ± 4.8</td>
<td>13.4 ± 4.8</td>
<td>ns</td>
</tr>
</tbody>
</table>

SD: standard deviation; ns: non significant
Table 3: Comparison of the teeth of the whole group and the follow-up group in terms of criteria for the difficulty of endodontic treatment (American Association of Endodontists, 2006) (21).

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>Whole group</th>
<th>Follow-up group</th>
<th>Pearson Chi Square Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=608)</td>
<td>(n=263)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% (n)</td>
<td>% (n)</td>
<td></td>
</tr>
<tr>
<td>Carious lesion</td>
<td>92.8% (564)</td>
<td>91.6% (241)</td>
<td>ns</td>
</tr>
<tr>
<td>Molar-Incisor Hypomineralisation</td>
<td>0.7% (4)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bruxism</td>
<td>0.7% (4)</td>
<td>0.8% (2)</td>
<td></td>
</tr>
<tr>
<td>Preparation for prosthetic</td>
<td>0.1% (1)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>rehabilitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>5.7% (35)</td>
<td>7.6% (20)</td>
<td></td>
</tr>
<tr>
<td>Tooth maturity</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Mature teeth</td>
<td>88% (535)</td>
<td>90.5% (238)</td>
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<tr>
<td>Immature teeth</td>
<td>12% (73)</td>
<td>9.5% (25)</td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Difficulty related to coronal</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>8.6% (52)</td>
<td>10.3% (27)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>68.3% (415)</td>
<td>84% (221)</td>
<td></td>
</tr>
<tr>
<td>High</td>
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<td>0</td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>23.1% (141)</td>
<td>5.7% (15)</td>
<td></td>
</tr>
<tr>
<td>Difficulty related to root canal</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>31.6% (192)</td>
<td>45.2% (119)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>33% (201)</td>
<td>39.2% (103)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>11.7% (71)</td>
<td>9.9% (26)</td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>23.7% (144)</td>
<td>5.7% (15)</td>
<td></td>
</tr>
<tr>
<td>Difficulty related to radiological</td>
<td></td>
<td></td>
<td>ns</td>
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<tr>
<td>appearance of root canal</td>
<td></td>
<td></td>
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<tr>
<td>Minimal</td>
<td>36% (219)</td>
<td>37.3% (98)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>30.3% (184)</td>
<td>38.8% (102)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>10.7% (65)</td>
<td>18.6% (49)</td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>23% (140)</td>
<td>5.3% (14)</td>
<td></td>
</tr>
</tbody>
</table>

ns: non significant
Table 4: Outcome of pulpotomy performed on permanent molars immediately restored with stainless steel crowns according to the follow up period in months (n = 263).

<table>
<thead>
<tr>
<th>Follow up evaluation (t = time in months)</th>
<th>Total per follow-up period</th>
</tr>
</thead>
<tbody>
<tr>
<td>t ≤ 6</td>
<td>6 &lt; t ≤ 12</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Effective pulpotomy</td>
<td>32% (75)</td>
</tr>
<tr>
<td>Uncertain pulpotomy</td>
<td>25% (5)</td>
</tr>
<tr>
<td>Ineffective pulpotomy</td>
<td>0</td>
</tr>
<tr>
<td>Total per follow-up period</td>
<td>30.4% (80)</td>
</tr>
</tbody>
</table>