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# Permanent teeth pulpotomy survival analysis: retrospective follow-up

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ABSTRACT

*Objectives:* The aim of the present study is to evaluate risk factors influencing the success rates of pulpotomies both in young and adult populations.
*Methods:* Pulpotomies ($n = 273$) performed by a single endodontic specialist were analyzed, and data on success rates were collected. Additionally, possible explanatory variables were noted such as: age, gender, clinical findings (teeth, type of restoration after pulpotomy), radiographic findings (dentin bridge formation) and systemic conditions. The follow-up period varied from 1 to 29 years, and the results were analyzed by Kaplan–Meier survival curves and also by Cox regression.
*Results:* Age at the time of pulpotomy ranged from 8 to 79 and had not influenced the success rates ($p = 0.35$). The formation of dentin bridge had a strong protective effect (hazard ratio—HR = 0.16, $p < 0.001$). The prosthetic crown restorations following pulpotomy had the smallest failure rate, and amalgam has not increased the risk of failure significantly in relation to prosthesis. Resin composite restorations following pulpotomy increased in 263% the risk of failure (HR = 3.63, $p < 0.001$).
*Conclusion:* This study allowed inferences that pulpotomy may be a successful treatment at any age, and not only for young permanent teeth. It was also possible to conclude that the use of direct composite restorations following pulpotomies is associated with higher failure rates.


## 1. Introduction

Pulp conservative treatments are options available to general dentists, both for deciduous and permanent teeth, and among therapies, pulpotomy is identified as one of the most effective [1–4]. The limited adoption of such technique in routine dental care needs to be revisited. Among the concerns stated, there is the possibility of dental resorption [5] or root canal calcification [1], which could jeopardize future endodontic treatment leading to tooth loss. On the other hand, some classic studies from de Sousa and Holland [6] and Holland and de Sousa [7], and also more recent research [1–4], have shown that pulpotomies have a success rate between 85% and 94%.

Studies such as Camp [8] contraindicate pulpotomy when there is spontaneous pain, which would suggest lack of tissue reaction ability. On the other hand, several other authors [4,9,10] have shown success following pulpotomy even when the clinical symptoms were of irreversible pulpitis. This brings up the debate as to what the actual situations are for success or failure of this technique.

It can be verified that the minimal use of is not due to possible technical difficulties, but perhaps to lack of incentive and/or a lack of clinical research that considers diagnostics, outcomes and follow-up [11]. There are time lapses and scarce long-term clinical databases for scientific research on pulpotomy, and this generates uncertainties about the clinical and radiographic behavior of pulpotomies and also about the predictability of such technique.

There is little conclusive clinical data on a long-term basis that considers clinical and systemic risk factors along with pulpotomy. Clinical information, such as pain symptoms and dentin bridge formation, or the influence of material selection on the restoration after pulpotomy, and also the possible interference of systemic risk factors (smoking, diabetes, hypertension, cardiopathy, and others) have motivated the present investigation.

This study has aimed to understand the clinical and radiographic behavior of 273 pulpotomies, with updated follow-up (from 1 to 29 years), performed by a single operator, and also to understand the risk factors on pulpotomy's survival rates.

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## 2. Materials and methods

This research was performed according international guidelines on research ethics, and the Brazilian research ethics committee under the number 14138413.8.0000.5336 approved it. All participants of this study signed a written informed consent.

Information from clinical records and radiographs was extracted from certified digital database from a single endodontic specialist practice from the beginning of the digital records in 1975 through 2014. Data on clinical, systemic and radiographic factors were collected, and also clinical recall was performed to determine an updated success rate on 273 permanent teeth pulpotomy cases (age range: 8 to 79 years old at the time of the procedure—Table 1). All cases were diagnosed, executed and followed by a single endodontic specialist throughout its career. Pulpotomy was selected as treatment based on clinical aspect of the dental pulp: (1) the tissue should be with adequate consistency (not being jelly or liquefied); (2) color presentation should be red or pink; (3) bleeding should follow cutting (lack of bleeding or color presentation as too light or cyanotic led to pulpectomy and conventional root canal treatment) [6,7] regardless of the pain diagnosis (with or without pain). Pure calcium hydroxide powder was selected in all cases as the pulp capping material regardless of the age of the patients.

The cases were not accidental pulp exposures. All patients were referred to the clinic for endodontic treatment and the specialist chose to perform pulpotomy as the final treatment whenever consistency and bleeding patterns allowed.

Cases were selected for treatment with pulpotomy according to clinical examination, in which there was a need for endodontic intervention but with no restorability issues. Periapical and bitewing radiographs were performed. Pulp sensitivity tests, until the late 80's, were conducted with ice stick and electrical test (Pulp Test, Pelton & Crane Company, North Carolina, USA). Later, thermal test with cooling sprays (−20, Aerojet, Rio de Janeiro, RJ, Brazil) were used.

Patient was anaesthetized and isolation with rubber dam was followed by removal of infected carious dentin and thorough irrigation with distilled water. With a new and sterilized bur, access was performed and coronal pulp was removed with a sharp bladed curette. Bleeding was washed away with distilled water until hemorrhage stopped. Under clear light, the aspect of the remaining pulp was assessed. If normal, a cotton pellet embedded in corticosteroid-antibiotic paste (Otosporin™, FQM, Rio de Janeiro, RJ, Brazil) was accommodated in contact with the surface of the remaining radicular pulp during five minutes. Then, washing with distilled water and drying with sterilized cotton pellet were followed by gentle placement of calcium hydroxide powder (Carlo Erba, São Paulo, SP, Brazil) with a sterilized amalgam carrier in close contact with the surface of the pulp. Care was taken to avoid pressure and load in this phase. Over the powder Dycal™ (Dentsply, Petrópolis, RJ, Brazil) was placed and then a temporary restoration with IRM™ (Dentsply, Petrópolis, RJ, Brazil) or glass ionomer (Vidrion R, SS White, Rio de Janeiro, RJ, Brazil) (Fig. 1).

Forty-eight hours following pulpotomy, patient was back for consultation and signs and symptoms were assessed. If everything were OK, patient was referred back to the dentist for final restoration, and scheduled for the first follow-up radiograph and clinical analysis 90 days following procedure.

In a second phase, the patients were contacted and invited to the practice for a new and free appointment to re-evaluate and update the clinical and radiographic condition of the pulpotomized teeth by a second and independent endodontic specialist. From a total of 567 pulpotomies, we could reach 281 patients and only 8 (2.85%) declined to participate. A number of 236 patients have changed phone number and address and we could not reach them (Table 2). Thirteen died, and 36 cases were performed less than one year before analyses and were not included.The reassessments were done according to the guidelines from the European Society of Endodontology [12]. Direct pulp capping and pulp amputation should be assessed no longer than 6 months postoperatively and thereafter at regular intervals. The following findings indicate favorable outcome: normal response to pulp sensitivity tests (when feasible), absence of pain and other symptoms, radiological evidence of dentine bridge formation, radiological evidence of continued root formation in immature teeth, absence of clinical and radiographic signs of internal root resorption and apical periodontitis, and risk factors data and success criteria were determined [12–15].

Teeth under analysis were considered together with periapical tissues, and determination of success and failure were defined as follows:

Success: lack of periapical radiolucency or widening of periodontal ligament apically; no pain following vertical or horizontal percussion; radiographic evidence of dentin bridge; lack of clinical or radiographic signs and symptoms of root resorption or apical periodontitis; positive response to sensitivity test, whenever possible.

Failure: presence of sinus tract; presence of periapical radiolucency; pain following percussion tests; clinical or radiographic signs and symptoms of root resorption or apical periodontitis; radiological widening of periodontal ligament; radiographic appearance of bone disturbance or loss.

Cases treated less than one year before the beginning of this study were excluded from our analyses. Minimal time of follow-up was 1 year and the maximum went up to 29 years(average follow-up time 4.75 year ± 5.96 years). Table 2 shows how the 273 pulpotomies were selected out of 567 cases.

Data was recorded in a Microsoft Excel (Microsoft Corp, Redmond, WA) database,and the following variables were collected: record number, gender, birth date, tooth number, pulpotomy date, age at the conclusion of the pulpotomy, number of appointments required to finish the pulpotomy, date of the last reevaluation on the pulpotomized teeth, determination of the success criteria (success or failure) of the pulpotomy, data of the last visit with successful pulpotomy or date of the failure (if this was the case), presence or absence of denting bridge formation detectable on the X-rays, failure cause (if was the case), systemic variables (smoking status, diabetes, hypertension, cardiopathy, and others), type of lining material (zinc phosphate, glass ionomer or other material), type of restoration after pulpotomy (prosthetic crown, amalgam or resin composite).

### 2.1. Statistical analyses

Initially, the survival rates of the pulpotomized teeth were evaluated and described by Kaplan–Meier curves. The evaluation of the risk factors was performed by Cox proportional-hazards regression in two ways: univariate analysis (non-adjusted model) and multivariate analysis (adjusted model). The Cox regressions results were presented by the hazard ratio coefficient (HR) and its respective 95% confidence interval (95% CI). For the specific analysis of tooth fracture occurrence, Fisher exact test was

**Table 1**
Age distribution at time of the pulpotomy.

| Age range | 08–10 | 11–20 | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 |
|---|---|---|---|---|---|---|---|---|
| Number of cases | 14 | 32 | 50 | 35 | 70 | 43 | 18 | 11 |