Review Article

Influence of Apical Diameter on the Outcome of Regenerative Endodontic Treatment in Teeth with Pulp Necrosis: A Review

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Abstract

Introduction: The aim of this review was to evaluate whether the apical diameter of teeth with necrotic pulp affects the outcomes of regenerative endodontic treatment and to determine the minimal apical size needed to obtain proper pulp revascularization. **Methods:** A literature search was performed from January 1, 2001, to November 25, 2016. Studies that satisfied the inclusion criteria were subjected to data extraction and analysis. **Results:** In total, 14 studies with 85 patients were included. There were 10 case reports, 3 case series, and 1 prospective cohort study. The apical diameters of the teeth were divided into 3 groups: a narrow-sized group (group N), <0.5 mm (n = 10); a medium-sized group (group M), 0.5–1.0 mm (n = 25); and a wide-sized group (group W), >1.0 mm (n = 60). In group N, 1 tooth failed, 2 teeth completely healed, and 7 teeth incompletely healed. In group M, 2 teeth were excluded, and 1 tooth failed. In group W, 3 teeth were excluded, and 4 teeth failed. The clinical success rates were 90%, 95.65%, and 92.98% in groups N, M, and W, respectively. **Conclusions:** Within the limitations, the teeth with apical diameters <1.0 mm achieved clinical success after regenerative endodontic treatment. Meanwhile, the teeth with apical diameters of 0.5–1.0 mm attained the highest clinical success rate, which may be related to other potential factors, including patient age, pulp necrosis etiology, preoperative apical radiolucency, procedure details, follow-up period, and sample size. *(J Endod 2017;■:1–18)*

Key Words

Apical (foramen) diameter, apical (foramen) size, pulp revascularization, regenerative endodontic treatment

Significance

The minimal apical foramen size for pulp revascularization was mainly discussed in autotransplanted or replanted teeth. The effect of the apical diameter on teeth with pulp necrosis in regenerative endodontics is rarely discussed.

A healthy dental pulp is important for the completion of root development in immature teeth (1). Pulp necrosis caused by trauma or infection may halt further root formation in immature teeth (2) and results in open apical foramina, large root canals, and thin canal walls (3). Conventional root canal therapy (RCT) cannot achieve complete cleaning and shaping as well as appropriate obturation for immature teeth (4, 5). Traditionally, apexification is the treatment of choice for immature teeth with open apices, and mineral trioxide aggregate (MTA) is more commonly used than calcium hydroxide ($Ca[OH]_2$) (6). Although apexification achieves clinical success by creating an apical barrier and promoting the healing of periapical lesions (7–9), it does not allow for any further root development in width and length of the dentin walls. As a result, the roots remain thin and fragile (10, 11). Besides, instrumentation and the compromised crown-to-root ratio render immature teeth further susceptible to fracture (4).

RCT is an effective treatment for mature teeth with favorable prognosis (12). However, a tooth without a vital pulp loses its defensive ability and becomes increasingly vulnerable to external forces. This decreased protection is often followed by tooth fracture and, ultimately, tooth extraction (13). Thus, functional pulps must be established by regenerative endodontics, and the prognosis of immature teeth may be improved by facilitating continued root formation.

The term revascularization originated from the dental trauma literature. In some cases, an avulsed tooth with incomplete root formation may be able to reestablish blood supply after autotransplantation or replantation (5). A successful revascularization case was first reported in 2001 (14). Meanwhile, revascularization procedures involve root canal disinfection and blood clot induction (15, 16). Several case reports showed successful results in clinics (eg, increased in root length and thickness and apical narrowing) (14, 17, 18). However, some reported unfavorable outcomes (19, 20).

Successful pulp regeneration relies heavily on the rapid and efficient formation of blood vessels. Teeth with large apices involve increased revascularization rates, mainly

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0099-2399/$ - see front matter

https://doi.org/10.1016/j.joen.2017.10.007

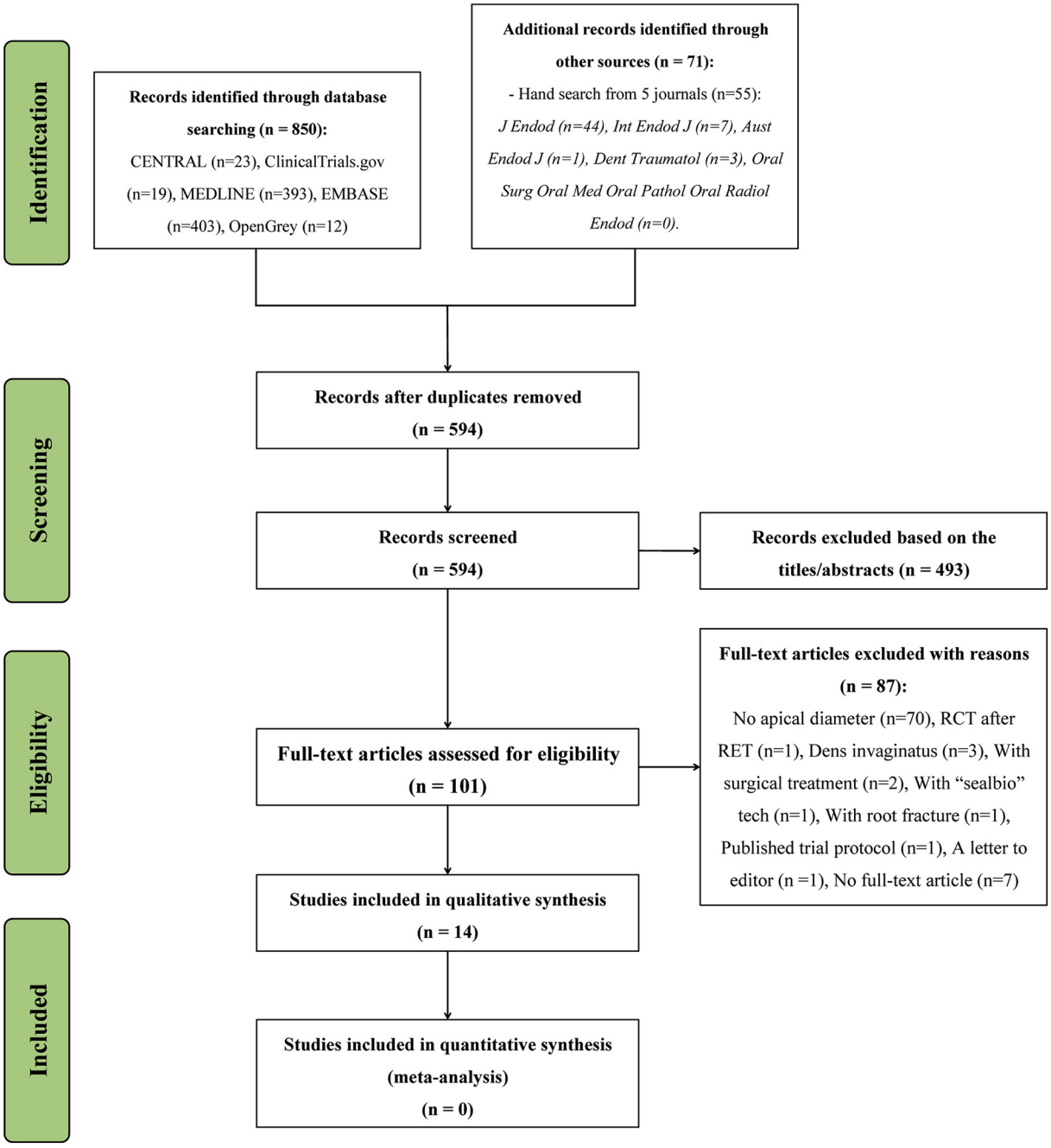

Figure 1. The flow diagram of the study selection process according to the PRISMA statement. *J Endod*, *Journal of Endodontics*; *Int Endod J*, *International Endodontic Journal*; *Aust Endod J*, *Australian Endodontic Journal*; *Dent Traumatol*, *Dental Traumatology*; *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*; RCT, root canal treatment; RET, regenerative endodontic treatment.

because of increased possible ingrowth of newly formed blood vessels (21). Therefore, the apical diameter is a significant factor in regenerative endodontics. An immature tooth seems more appropriate than a mature tooth for dental pulp regeneration given the wider apical size and higher amount of apical stem cells of the former than those of the latter. However, several studies (22, 23) reported clinical success in mature teeth that underwent regenerative endodontic treatment (RET).

The minimal apical foramen size of teeth for successful outcomes was discussed in several studies of dental traumatology. Apical sizes <1.0 mm prevent pulp revascularization in reimplanted permanent incisors (21). Avulsed teeth with apical diameters <1.5 mm achieve the lowest pulp revascularization rate after replantation (24). An apical size <1.0 mm allows pulp revascularization, and even an apical foramen of 0.32 mm does not limit new tissue formation in beagle dogs (25). Inconsistency in the previously mentioned studies may be because of the relationships among several factors (eg, storage conditions, extra-alveolar time, root length, apical diameter approaches, definitions of success, evaluation methods, and follow-up periods).

To date, published studies on the minimal apical size of teeth that underwent RET are rare. Successful results were reported with apical sizes of 0.6, 0.7, and 0.8 mm in mature animal teeth by different