



Symmetry of the Final Working Length in Multicanal Teeth: A Review of Anatomical Principles and Clinical Implications

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Abstract

Accurate determination of the final working length (WL) is central to successful endodontic therapy in teeth with multiple root canals. Because the apical constriction cannot be visualised directly, clinicians rely on anatomical landmarks, radiographs, electronic apex locators (EALs) and, increasingly, on the observation that canals within the same tooth, and homologous teeth on opposite sides of the arch, tend to terminate at comparable depths. This review examines the anatomical evidence underpinning this principle of 'working length symmetry' in multicanal teeth and its clinical relevance. A narrative literature search of PubMed/MEDLINE, Scopus and Google Scholar was performed using combinations of the terms working length, apical constriction, symmetry, multicanal, contralateral and bilateral. Three levels of symmetry emerged from the literature: (1) orifice-level symmetry, described by Krasner and Rankow's laws of pulp-chamber-floor anatomy; (2) intraradicular symmetry, in which the apical constrictions of two canals within the same root (for example, the first and second mesiobuccal canals) occupy comparable positions relative to the anatomical apex; and (3) bilateral, or contralateral, symmetry, in which homologous teeth on the two sides of the same arch show a high, though incomplete, correspondence in root length, canal configuration and apical anatomy. Micro-computed tomography and cone-beam computed tomography studies broadly support these observations, although exceptions are frequent enough that symmetry should be used only as a corroborative, not a definitive, guide. Combining anatomical symmetry with radiographic and electronic confirmation offers the most reliable approach to establishing the final working length in multicanal teeth, reducing the risk of under- or over-instrumentation and of missed canals.

Keywords: Working length; apical constriction; root canal symmetry; multicanal teeth; electronic apex locator; endodontics

1. Introduction

The working length (WL) of a root canal is defined as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate [1]. Histological and micro-anatomical work has consistently identified this terminus as lying at, or close to, the apical constriction, the narrowest part of the canal, which is usually located 0.5–1.0 mm coronal to the apical foramen [1–2]. Establishing an accurate WL is one of the most important, and most error-prone, steps of root canal treatment: under-extension risks leaving necrotic tissue and debris in the apical segment, while over-extension may damage the periapical tissues, cause postoperative pain, or compromise the biological seal [3].

The difficulty of WL determination is compounded in multicanal teeth. Maxillary molars, mandibular molars and many premolars contain two or more canals within the same tooth, and often within the same root, each of which must be independently negotiated, measured and shaped to its own apical terminus. The mesiobuccal root of the maxillary first molar, for example, frequently contains a second mesiobuccal (MB2) canal in addition to the main MB1 canal, and failure to locate and adequately instrument this canal remains a recognised cause of endodontic failure. In such teeth, clinicians commonly use the working length of an already-negotiated canal as a reference point from which to estimate the length of an adjacent, more elusive canal, an approach that rests implicitly on the assumption that canals within the same



tooth, and even within the same arch position on opposite sides of the mouth, terminate at broadly similar depths.

This assumption of anatomical symmetry operates at more than one level. At the coronal, or orifice, level it is formalised in the classic anatomical ‘laws of symmetry’ described by Krasner and Rankow, which relate the position of canal orifices on the pulp-chamber floor to lines of reference drawn across that floor [4]. At the apical level, several micro-computed tomography (micro-CT) and sectioning studies have examined whether the apical constrictions of two canals sharing a single root occupy comparable positions relative to the anatomical apex. At the level of the whole dentition, cone-beam computed tomography (CBCT) and micro-CT studies of contralateral (left–right homologous) teeth have asked whether root length, canal configuration and apical anatomy on one side of the arch can be used to predict the corresponding anatomy on the other side.

The aim of this review is to synthesise the anatomical evidence for symmetry of the final working length across these three levels in multicanal teeth, to relate this evidence to established techniques of working length determination, and to identify the limitations that should temper reliance on symmetry as a clinical shortcut.

2. Materials and Methods

This is a narrative review rather than a systematic review, and no formal protocol was registered. A literature search was conducted in PubMed/MEDLINE, Scopus and Google Scholar for articles published up to 2026, using combinations of the search terms “working length”, “apical constriction”, “symmetry”, “multicanal”, “mesiobuccal canal”, “contralateral”, “bilateral”, “Krasner Rankow”, “CBCT” and “micro-CT”, combined with the Boolean operators AND/OR. Reference lists of retrieved articles were hand-searched for additional relevant sources.

Articles were included if they were published in English, reported original anatomical, radiographic or clinical data (ex vivo, in vitro, in vivo, micro-CT- or CBCT-based), or were widely cited classic anatomical descriptions relevant to working length or pulp-chamber and root-canal symmetry. Conference abstracts without full text, non-peer-reviewed material and articles not available in English were excluded. Because this review draws on human, non-interventional anatomical and imaging literature that did not involve new data collection on patients by the author, no separate ethical approval or informed consent procedure was required for the preparation of this manuscript. Data relevant to working length, apical constriction position, orifice location and bilateral or intraradicular symmetry were extracted narratively and organised under the three levels of symmetry described above (orifice, intraradicular and bilateral) for qualitative synthesis; given the heterogeneity of study designs and outcome measures, a quantitative meta-analysis was not attempted.

3. Results and Discussion

3.1 Anatomical basis of the working length

The apical constriction is generally accepted as the ideal apical limit for canal preparation and obturation because it marks the approximate transition between pulpal and periodontal tissue, and its preservation helps to confine instrumentation and filling materials within the root canal system [1–3]. Micro-CT evaluation of 271 canals in 90 human molars confirmed that a true constriction was identifiable in the great majority of canals, with a mean distance from the constriction to the apical foramen of about 0.2 mm and to the anatomical apex of about 0.9 mm, findings that were independent of canal type (mesiobuccal, distobuccal or palatal) [5]. Similar constriction-to-foramen distances of roughly 0.7–0.85 mm have been reported when comparing molars and incisors, with molars showing a slightly shorter, but statistically different, distance than single-rooted incisors [6]. These figures provide the population-level anatomical backdrop against which symmetry between individual canals, roots and teeth can be assessed.

3.2 Orifice-level symmetry: the laws of Krasner and Rankow

The earliest and most widely taught formalisation of dental symmetry relevant to endodontics is not apical but coronal. Krasner and Rankow examined 500 extracted teeth, sectioning 400 horizontally at the cemento-enamel junction and 100 either bucco-lingually or mesio-distally, and proposed a series of anatomical ‘laws’ governing the pulp-chamber floor [4]. Among these, the two laws of symmetry state that, except in maxillary molars, the orifices of the root canals are equidistant from a line drawn in a mesiodistal direction through the centre of the pulp-chamber floor (Law of Symmetry 1), and that these orifices lie on a line perpendicular to that same mesiodistal line (Law of Symmetry 2) [4]. These laws, together with the laws of centrality, concentricity and orifice location, are used clinically to predict the presence and approximate position of unlocated canal orifices, including additional or missed canals, from the position of orifices that have already been identified [4].

Although the Krasner and Rankow laws describe orifice position rather than apical termination, they are clinically relevant to working length symmetry because they establish, at the coronal end of the canal, the same underlying anatomical regularity that is later examined apically: canals within a tooth are not randomly distributed but follow predictable geometric relationships to one another. This orifice-level regularity is the anatomical starting point from which many clinicians extrapolate an expectation of comparable canal length.

3.3 Intraradicular symmetry: apical constrictions of two canals in the same root

Where a single root contains two canals, as in the mesiobuccal root of the maxillary first molar (MB1/MB2) or in many mandibular incisors and premolars, the more clinically pressing question is whether the apical constrictions of the two canals occupy comparable depths. Foraminal morphology

studies of maxillary and mandibular molars using cleared and sectioned specimens found that, in roots with two canals, the apical constrictions of the two canals were of very similar dimensions, although the buccal canal constriction tended to be somewhat wider than that of the corresponding lingual or palatal canal [7–8]. A parallel micro-CT investigation of premolars extended these observations, confirming that physiological foramen morphology in roots with more than one canal follows broadly comparable, though not identical, patterns between the two canals of the same root [8]. Comparative micro-CT analysis of apical constriction morphotypes in maxillary molars similarly found no significant difference in constriction dimensions between mesiobuccal, distobuccal and palatal canals of the same tooth, supporting a degree of apical uniformity across canals sharing a common root complex [9].

Taken together, this body of work indicates that, while the two canals of a divided root are seldom perfectly identical in constriction diameter or shape, their apical terminations tend to lie at closely comparable depths relative to the anatomical apex. This is the anatomical basis for a widely used clinical technique in which the working length of an already-negotiated canal (for example, MB1) is used as a first approximation for an adjacent, more difficult canal (MB2) sharing the same root, pending confirmation by radiograph or electronic apex locator.

3.4 Bilateral (contralateral) symmetry across the arch

A separate, and increasingly well-studied, level of symmetry concerns homologous teeth on opposite sides of the same arch. Using CBCT, Plotino and colleagues analysed the root and root-canal morphology of maxillary and mandibular first and second molars in a white population and found that a substantial majority of contralateral tooth pairs, roughly seven in ten first molars and eight in ten second molars, showed what they classified as perfect bilateral symmetry of root and canal configuration [10]. Building on this theme, a recent CBCT-based analysis of the second mesiobuccal (MB2) canal found strong agreement between contralateral maxillary first molars (approximately 92% concordance) and contralateral second molars (approximately 79% concordance) for both the presence and the Vertucci configuration of the MB2 canal, whereas agreement between adjacent or non-homologous molars in the same arch was markedly lower, at around 60% [11]. A separate *ex vivo* CBCT study of contralateral maxillary first and second molars likewise reported close correspondence in additional canal prevalence between paired teeth [12]. At the level of individual root anatomy rather than canal number, a micro-CT geometric morphometric analysis of 60 pairs of extracted contralateral mandibular incisors found a statistically higher similarity between contralateral pairs than between randomly matched teeth across five of six measured geometric parameters, supporting the use of the contralateral tooth as an anatomically informative reference [13].

These findings collectively suggest that the working length established for a tooth on one side of the arch can serve as a

reasonable, though imperfect, first estimate for the homologous tooth on the opposite side, particularly for first molars, where bilateral agreement is consistently highest. The agreement is weaker, and should be trusted correspondingly less, between adjacent teeth of different types (for example, a first molar and a second molar) than between two homologous teeth of the same type on opposite sides of the same arch [11].

3.5 Clinical application of the symmetry principle to final working length

In practice, the symmetry principle is applied at several points in treatment. Preoperatively, an existing radiograph or CBCT scan of a contralateral tooth, taken for an unrelated reason, can be used to anticipate root curvature, canal number and probable working length before treatment of the tooth in question begins, reducing the number of additional exposures required [11–12]. Intraoperatively, once one canal of a multicanal tooth has been reliably negotiated to its apical constriction and its working length confirmed, this length is commonly used as the first working estimate for an adjacent canal in the same root, or for a bilaterally symmetrical canal in a homologous root, with the file advanced cautiously and the estimate refined using tactile sensation, an electronic apex locator, and a confirmatory radiograph [4,7–9]. Used in this way, symmetry functions as a means of generating an informed starting hypothesis, narrowing the range within which the true apical constriction is likely to lie, rather than as a substitute for direct verification.

This is consistent with the wider literature on working length determination, which consistently favours a combined approach. A recent systematic review and meta-analysis of sixteen studies comparing electronic apex locators with conventional and digital radiography found that electronic apex locators achieved acceptable working length determinations in 87–92% of cases, compared with 74–83% for radiographs alone, with a lower incidence of overextension in the electronic apex locator groups [14]. Because neither method is infallible, combining radiographic, electronic and anatomical (symmetry-based) information, rather than relying on any single source, offers the most robust estimate of the true apical constriction in a multicanal tooth.

3.6 Limitations and pitfalls of relying on symmetry

The symmetry principle, at every level examined, is a strong statistical tendency rather than an anatomical certainty, and several sources of variation temper its clinical use. First, bilateral symmetry is imperfect even for the most consistent tooth groups: agreement rates of roughly 70–92% for canal configuration and prevalence still leave a meaningful minority of tooth pairs that are genuinely asymmetrical, and this proportion falls further for second molars, for less common canal configurations, and for teeth that are not directly homologous [10–11]. Second, intraradicular symmetry of apical constriction dimensions is not absolute: buccal canal constrictions have been reported to be measurably wider than their lingual or palatal counterparts within the same root, and constriction morphology (parallel, tapering, multiple or absent) varies between individual canals even when overall

depth is comparable [7–9]. Third, and most fundamentally, the apical constriction itself is a biological, not a fixed geometric, landmark: it may be absent, multiple, or difficult to define histologically in a minority of canals, and its position can be altered by resorption, calcification, prior instrumentation, or canal curvature, none of which is reliably predicted by the anatomy of a neighbouring canal or a contralateral tooth [2–3]. For these reasons, symmetry-derived estimates of working length should always be treated as provisional and confirmed independently before being finalised for canal preparation and obturation.

3.7 Verifying symmetry-based estimates with electronic and radiographic methods

Given these limitations, an estimate of working length obtained by symmetry, whether from an adjacent canal in the same root or from a contralateral tooth, should be treated as a starting hypothesis to be refined rather than a final value. Electronic apex locators offer a chairside means of confirming or adjusting a symmetry-based estimate for each individual canal, and their accuracy is generally superior to radiographs alone, particularly in reducing the frequency of overextension [14]. A confirmatory working length radiograph, ideally combined with electronic apex locator readings, remains a reasonable final check, particularly when canal curvature, calcification, or an atypical response from the apex locator raises doubt about whether the anticipated symmetrical length is in fact correct. Preoperative CBCT, where clinically indicated, offers the most direct means of assessing bilateral and intraradicular symmetry in advance of treatment, but should be reserved for cases in which the additional information is likely to materially change management, in keeping with current radiation-dose guidance [11].

4. Conclusion

Multicanal teeth display a consistent, though not absolute, tendency towards symmetry of the final working length at three anatomical levels: orifice location on the pulp-chamber floor, apical constriction depth between canals sharing a single root, and root and canal anatomy between homologous teeth on opposite sides of the arch. This symmetry provides a useful clinical heuristic for anticipating the length of an as-yet unlocated or difficult canal from one that has already been established, and can reduce missed canals and unnecessary radiographic exposure when applied thoughtfully. However, because bilateral and intraradicular agreement, while frequent, is never universal, symmetry should be used only as a corroborative guide alongside, and never as a replacement for, direct confirmation of the apical constriction by tactile sensation, electronic apex locator and radiograph for every canal individually instrumented.

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Conflict of Interest

The author declares no conflict of interest.

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