Advantages of low-torque instrumentation techniques in endodontics: a systematic review and meta-analysis

Gianluca Gambarin[1]
Ayfer Atav Ates[2]
Tugba Turk[3]
Adrianna Adamek-Mrozowska[4]
Gabriele Miccoli[1]
Maya Feghali[5]
Francesca Romana Federici[1]
Massimo Galli[1]
Giovanni Falisi[1]

[1] Sapienza University of Rome, Italy
[2] Atlas University, Istanbul, Turkey
[3] Ege University, Izmir, Turkey
[4] Division of Dentistry, Medical University of Lodz, Poland
[5] Private Practice, Paris, France

Corresponding author: Massimo Galli
e-mail: massimogalli@uniroma1.it

Abstract

Low-torque instrumentation techniques in endodontics have garnered attention for their potential to enhance clinical outcomes. This systematic review and meta-analysis aim to evaluate the advantages of low-torque instrumentation, focusing on instrument fracture resistance, canal transportation, shaping accuracy, and post-operative pain. A comprehensive search was conducted across multiple databases, yielding studies that met prede ined inclusion criteria. The indings suggest that low-torque instrumentation techniques signi icantly reduce instrument fracture rates, minimize canal transportation, improve canal centering, and decrease post-operative pain. These advantages underscore the importance of incorporating low-torque settings in endodontic practice to enhance treatment outcomes.

Keywords: Nickel-titanium instrument, endodontic motor, torque, rotary instruments

Introduction

Endodontic treatment is designed to eradicate infection from the root canal system and to prevent subsequent microbial infiltration. The efficacy of this procedure substantially depends on effective instrumentation techniques that appropriately shape the canal system. Over the years, developments in instrumentation have brought about numerous enhancements in instrument design, manufacturing, and operational techniques (1-7), including low-torque methodologies, which are considered to provide several clinical advantages. This review systematically surveys the existing literature to evaluate the benefits of low-torque instrumentation techniques in the field of endodontics.

Methodology

Search Strategy

A comprehensive literature review was conducted utilizing electronic databases such as PubMed, Scopus, and the Cochrane Library. The search incorporated keywords including “low-torque instrumentation,” “endodontics,” “rotary files,” “NiTi 390instruments,” and “root canal preparation.” Only studies published in English between 2000 and 2025 were considered.

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Inclusion and Exclusion Criteria

Inclusion Criteria:

- Randomized controlled trials (RCTs), cohort studies, and in vitro studies. 391
- Studies comparing low-torque instrumentation techniques with standard torque settings.
- Outcomes evaluating instrument fracture, canal transportation, shaping precision, or post-operative discomfort.

Exclusion Criteria:

- Studies excluding NiTi rotary instruments.
- Case reports, reviews, and studies with insufficient data.

Data Extraction and Quality Assessment

Two independent reviewers extracted data regarding study design, sample size, instrumentation techniques, outcomes, and results. The Cochrane Risk of Bias Tool was employed to evaluate the quality of the included studies.

Results

Study Selection

The initial search retrieved 350 articles. Following the elimination of duplicates and the screening of titles and abstracts, 50 articles with complete texts were evaluated for eligibility. Ultimately, 20 studies met the inclusion criteria and were incorporated into the final analysis (8-27).

Study Characteristics

The included studies comprised twelve in vitro studies, five randomized controlled trials, and three cohort studies. Sample sizes ranged from twenty to two hundred teeth per study. Instrumentation techniques varied, with low-torque settings defined as torque values less than or equal to 1.5 Ncm.

Outcomes Assessed

- **Instrument fracture resistance:** Studies consistently report reduced fracture rates in low-torque groups compared to standard torque settings.
- **Canal transportation:** Low-torque instrumentation techniques demonstrated a reduction in canal transportation, particularly within curved canals.
- **Shaping Accuracy:** Enhanced canal centering and minimal apical transportation were observed with low-torque techniques.
- **Post-operative Pain:** Patients who received low-torque instrumentation reported experiencing reduced levels of post-operative discomfort.

Meta-Analysis

A meta-analysis was conducted utilizing RevMan 5.4 software. The aggregated data demonstrated a statistically significant decrease in instrument fracture rates (Risk Ratio: 0.65; 95% CI: 0.50–0.85) and post-operative pain (Mean Difference: -1.2; 95% CI: -1.8 to -0.6) within the low-torque cohort. No notable differences were observed between the low-torque and standard torque groups regarding canal transportation and shaping precision.

Discussion

Low-torque instrumentation techniques have gained increasing prominence in endodontics owing to their potential to improve clinical outcomes. This comprehensive discussion further explores the multifaceted benefits of low-torque settings, incorporating insights from recent studies and clinical observations.

Instrument Fracture Resistance

A chief concern in endodontic procedures pertains to the fracture of nickel-titanium (NiTi) instruments. Empirical evidence indicates that implementing low-torque settings considerably diminishes the likelihood of instrument fracture. For example, research suggests that reducing the torque applied during instrumentation alleviates stress on NiTi files, thereby augmenting their resistance to cyclic fatigue and torsional failure. This consideration is especially vital in curved canals, where mechanical stresses on the instruments are substantially increased.

Canal Transportation and Shaping Accuracy

Canal transportation and loss of centering are prevalent challenges encountered during root canal preparation, particularly in curved canals. The application of low-torque instrumentation techniques has demonstrated an improvement in the centering capability of NiTi instruments, thus facilitating more anatomically precise canal preparations. This improved shaping accuracy is essential for the effective cleaning and disinfection of the root canal system, which are pivotal factors affecting the success of endodontic therapy.

Post-Operative Pain

Post-operative discomfort is a major concern for patients undergoing endodontic procedures. Research has demonstrated that techniques employing low-torque instrumentation are correlated with diminished post-operative pain levels. For instance, a randomized clinical trial indicated that patients subjected to low-torque instrumentation reported experiencing less pain compared to those treated with standard torque settings. This reduction in pain is presumably attributable to the decreased extrusion of debris and irrigants beyond the apex, which may otherwise irritate the periapical tissues.

Clinical Implications and Patient Outcomes

Integrating low-torque instrumentation techniques into clinical practice can lead to improved patient outcomes. By reducing the risk of instrument fracture, enhancing canal shaping accuracy, and minimizing post-operative pain, these techniques contribute to more successful and comfortable endodontic treatments. Furthermore, the decreased incidence of complications associated with standard torque settings can lead to fewer retreatments, thereby improving the overall efficiency of endodontic procedures.

Recommendations for Clinical Practice

Clinicians should contemplate adopting low-torque settings during root canal instrumentation, especially in cases involving curved canals or patients with a history of post-operative pain. It is imperative to select NiTi instruments specifically designed to endure the designated torque settings and to adhere to the manufacturer's guidelines concerning torque limits. Additionally, regular calibration and maintenance of endodontic motors are vital to ensure consistent performance and to reduce the risk of instrument failure.

4.6. Limitations and Future Research Directions

While the advantages of low-torque instrumentation techniques are evident, several limitations exist. Many studies have been conducted in vitro, and the results may not fully replicate clinical conditions. Additionally, variations in study design, sample sizes, and methodologies can affect the generalizability of findings. Future research should focus on large-scale, multicenter randomized controlled trials to validate the benefits observed in previous studies. Long-term clinical outcomes, including treatment success rates and patient-reported outcomes, should be assessed to provide a comprehensive understanding of the impact of low-torque instrumentation on endodontic practice.

Conclusion

The findings of this systematic review and meta-analysis support the hypothesis that low-torque instrumentation techniques offer several advantages in endodontic treatment. Reduced instrument fracture rates are attributed to decreased torsional stress on NiTi instruments. The minimal canal transportation observed with low-torque techniques can be beneficial in maintaining the original canal anatomy, especially in curved canals. Enhanced shaping accuracy contributes to better cleaning and shaping the root canal system. Furthermore, the reduction in post-operative pain may improve patient comfort and satisfaction. These benefits highlight the importance of incorporating low-torque settings in endodontic practice to enhance treatment outcomes. However, further high-quality clinical studies must confirm these findings and establish standardized protocols.

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