Hand and ultrasonic instrumentation for orthograde root canal treatment of permanent teeth

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Hand and ultrasonic instrumentation for orthograde root canal treatment of permanent teeth

Vinícius PEDRAZZI¹, Jeronimo Manço de OLIVEIRA-NETO², Patrick SEQUEIRA³, Zbys FEDOROWICZ⁴, Mona NÄSSER⁵

1- DDS, MSc, PhD Associate Professor, Department of Dental Materials and Prosthodontics, Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, SP, Brazil.
2- DDS MSc student, Department of Dental Materials and Prosthodontics, Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, SP, Brazil.
3- BDS, DMD, MSc Specialist, Department of Preventive, Restorative and Pediatric Dentistry, University of Bern, Bern, Switzerland.
4- BDS, MSc, DPH Director, Bahrain Branch of the UK Cochrane Center, Awali, Bahrain.
5- DDS, MSc, Researcher, Department of Health Information, Institute for Quality and Efficiency in Healthcare (IQWIG), Cologne, Germany.

Corresponding address: Prof. Dr. Vinícius Pedrazzi - Departamento de Materiais Dentários e Prótese - Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo - Av do Café s/nº - 14040-904 - Ribeirão Preto, SP - Brazil - Phone: + 55 16 3602-4008 - Fax:+ 55 16 3602-0547 - e-mail: pedrazzi@forp.usp.br

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ABSTRACT

Root canal treatment is a frequently performed dental procedure and is carried out on teeth in which irreversible pulpitis has led to necrosis of the dental pulp. Removal of the necrotic tissue remnants and cleaning and shaping of the root canal are important phases of root canal treatment. Treatment options include the use of hand and rotary instruments and methods using ultrasonic or sonic equipment. Objectives: The objectives of this systematic review of randomized controlled trials were to determine the relative clinical effectiveness of hand instrumentation versus ultrasonic instrumentation alone or in conjunction with hand instrumentation for orthograde root canal treatment of permanent teeth. Material and Methods: The search strategy retrieved 226 references from the Cochrane Oral Health Group Trials Register (7), the Cochrane Central Register of Controlled Trials (CENTRAL) (12), MEDLINE (192), EMBASE (8) and LILACS (7). No language restriction was applied. The last electronic search was conducted on December 13th, 2007. Screening of eligible studies was conducted in duplicate and independently. Results: Results were to be expressed as fixed-effect or random-effects models using mean differences for continuous outcomes and risk ratios for dichotomous outcomes with 95% confidence intervals. Heterogeneity was to be investigated including both clinical and methodological factors. No eligible randomized controlled trials were identified. Conclusions: This review illustrates the current lack of published or ongoing randomized controlled trials and the unavailability of high-level evidence based on clinically relevant outcomes referring to the effectiveness of ultrasonic instrumentation used alone or as an adjunct to hand instrumentation for orthograde root canal treatment. In the absence of reliable research-based evidence, clinicians should base their decisions on clinical experience, individual circumstances and in conjunction with patients’ preferences where appropriate. Future randomized controlled trials might focus more closely on evaluating the effectiveness of combinations of these interventions with an emphasis on not only clinically relevant, but also patient-centered outcomes.

Key words: Permanent dentition. Ultrasonic therapy. Root canal therapy.

INTRODUCTION

Root canal treatment is a procedure that is very frequently performed in dentistry with the aim of retaining teeth. As a treatment option, it offers an alternative to tooth extraction and is carried out on teeth in which irreversible pulpitis has led to necrosis of the dental pulp. Orthograde root canal treatment entails drilling into the pulp chamber of the tooth which contains the dental pulp. The pulp, which may be inflamed or necrotic, is removed and the root canal is then cleaned and prepared. The objectives of root canal treatment are the elimination of infection from the
root canal and the prevention of its reinfection by
the filling and sealing of the root canal space5,16.

It is generally recognized that a cleaner root
 canal system should lead to improved outcomes7
and that successful root canal treatment may
prolong the retention of the tooth as a functional
unit in the mouth.

Some of the problems encountered in the
 cleaning and shaping of root canals have led to a
wide search for innovative materials, instruments
and techniques which might permit a faster and
more effective way of achieving a disinfected and
debris-free canal that is ready for obturation. Apart
from the traditional methods of using hand and
rotary instruments, more recent techniques have
employed lasers, non-instrumentation techniques
(NIT), and methods using ultrasonic or sonic
equipment. A number of studies have shown that
endodontic files which have been activated by
ultrasonic energy may be effective in both the
cleaning and shaping of root canal systems18.

Hand instrumentation is the traditional method
of preparation of root canals and involves the use
of files to clean and shape the root canals with the
aim of removing pulpal tissue, infected debris and
some of the inner, infected pulpal dentine. Copious
irrigation to flush the canal accompanies this
instrumentation. The second aim is to shape the
canal in such a way that it can be filled completely
to prevent the canal becoming further infected by
microorganisms.

Using ultrasonic devices in addition to hand
instrumentation presupposes that benefits may
accrue and outcomes may be improved when
compared to hand instruments alone. Ultrasound
is sound energy with a frequency over 20,000
oscillations per second. The first commercial
machine designed for cleaning and disinfecting
the root canal was introduced 30 years ago14. This
process involves the activation of a file with
ultrasound which can then be used to both clean
and shape the dentine of the root canal. Ultrasound
instrumentation can be used either as a primary
cleaning and shaping technique or after hand
instrumentation. These two techniques require the
active movement by the operator of the ultrasonic
instrument against the canal walls. Alternatively,
ultrasonic energy can be applied passively, without
any contact with the canal walls and without any
movement of the instrument after activation is
started10. It was previously believed that it was
necessary to move the file in the canal. However,
more recent microscopic observation suggests that
it is only necessary to bring ultrasonic energy into
the canal, and that even a straight, blunt passive
wire will transmit enough energy to clean the canal
further.

A well recognized difficulty that can arise during
ultrasonic preparation is the accurate control of the
cutting effect of the file19. Ultrasonic instrumentation
may also result in lengthier treatment time, and the
operational and maintenance requirements of the
ultrasonic equipment may add substantially to the
treatment cost.

Hand instrumentation of root canals requires
irrigation to remove the debris produced. This
irrigation may be carried out with fine syringes
introduced into the canal orifice. Alternatively,
ultrasonic irrigation of root canals can be
performed with or without simultaneous ultrasonic
instrumentation20.

Successful root canal treatment is characterized
by the absence of symptoms and clinical signs and
any radiographic signs of periodontal involvement6.
The success of orthograde root canal treatment
depends on a series of variables some related to the
pre-operative conditions of the tooth as well as the
endodontic procedures9, with curved canals posing
possibly some of the most significant challenges.
Whilst it is perceived that the improved cleaning
that occurs with ultrasonic instruments may lead
to improved outcomes for endodontically treated
teeth, complications may arise. Complications can
be broadly divided into four categories:

1. Blockage, ledging, and loss of working length
   in the canal
2. Deviations from the normal canal or root
   anatomy
3. Excessive or inadequate canal preparation
4. Breakage of instruments in the canal

Root canal treatment has a good degree of
success (approximately 80%)12. However, root canal
treatment can fail, usually due to technical reasons.
Even when technical excellence is attained, failure
may still ensue from remaining infection, because
of the nature of the root canal and the inability of
current methods to completely clean and fill all its
niches15. If ultrasonic instrumentation is able to
more effectively clean the root canal then it may be
expected to result in improved treatment outcomes.

Ultrasonic irrigation of the root canals can be
performed with or without simultaneous ultrasonic
instrumentation. Passive ultrasonic irrigation (PUI)
can be an important supplement for cleaning the
root canal system and, compared with traditional
syringe irrigation, is capable of removing more
organic tissue, bacteria and dentin debris from
the root canal system. It has been claimed that
PUI is more efficient in cleaning canals than
ultrasonic irrigation with simultaneous ultrasonic
instrumentation20.

The objectives of this systematic review of
randomized controlled trials were to determine
the relative clinical effectiveness of hand
instrumentation versus ultrasonic instrumentation
alone or in conjunction with hand instrumentation

for orthograde root canal treatment of permanent teeth.

MATERIAL AND METHODS

A systematic review of randomized controlled trials comparing hand instrumentation versus ultrasonic instrumentation alone or as and adjunctive procedure to hand instrumentation for orthograde root canal treatment of permanent teeth was undertaken. Only trials with adult participants (≥18 years old) with single and multiple permanent teeth with completely formed apices, and no evidence of internal resorption requiring root canal treatment were included in the review. Patients undertaking re-treatment of a tooth were excluded. The outcomes included were as follows:

Primary outcomes
(1) Proportion of teeth retained for at least 12, 24, 36 and 48 months and their periapical status as confirmed by radiograph.
(2) Total time required for preparation technique and number of visits.
(3) Postoperative pain: self assessment of pain measured on a visual analogue scale or similar, use of pain medication and antibiotic medicine (type, dosage and amount).

Secondary outcomes
(1) Any unscheduled re-visit or emergency visit.
(2) Any quality of life or patient satisfaction outcomes measured on a validated scale.

For the identification of studies included or considered for this review, detailed search strategies were developed for each of the following databases:
The Cochrane Oral Health Group Trials Register (whole database, to December 13th, 2007);
The Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library Issue 4, 2007 – 17 October 2007);
MEDLINE (via OVID) (without filter) (from 1966 to December, 13th 2007);
EMBASE (via OVID) (without filter) (from 1980 to December, 13th 2007);
Latin American and Caribbean Literature on Health Sciences (LILACS) (via BIREME) (without filter and no date limit) (on December, 13th 2007).

The search strategy retrieved 226 (7 Cochrane Oral Health Group Trials Register, 12 CENTRAL, 8 EMBASE, 192 MEDLINE, 7 LILACS) references. All databases were searched up to 13 December 2007. Search strategies were developed for MEDLINE, but were revised appropriately for each database.

The reference lists of the potentially eligible clinical trials and the review authors’ personal databases of trial reports were also searched in an attempt to identify any other relevant studies. There were no language restrictions on included studies and we translated one relevant non-English paper.

The abstracts of studies resulting from the searches were independently assessed by three reviewers (Patrick Sequeira, Zbys Fedorowicz and Jeronimo Manço de Oliveira Neto), and all irrelevant studies were excluded. Full-text reprints of all relevant and potentially relevant studies, that is, those appearing to meet the inclusion criteria, or those that had insufficient information in the title and abstract to make a clear decision, were obtained. The full-text reprints were assessed independently by these three review authors, and any disagreement on the eligibility of included studies was discussed and resolved. Studies not matching the inclusion criteria were excluded from further review, and their details and reasons for their exclusion were recorded.

Although no eligible randomized controlled trials met the inclusion criteria for inclusion in the present investigation, the following methods were to be applied and will be used if further trials are identified for inclusion in any updates of this review.

Assessment of methodological quality
Grading and assessment of the selected studies was to be done independently by two review authors (Vinicius Pedrazzi and Jeronimo Manço de Oliveira Neto), and according to the criterion grading system described in the Cochrane Handbook for Systematic Reviews of Interventions 4.2.6.

Data collection
Study details and outcomes data were to be collected using a predetermined form designed for this purpose. Extracted data were to be entered separately by each of two review authors (Mona Nasser and Patrick Sequeira) into the “Characteristics of included studies” table in RevMan 4.2, and were automatically checked for differences. Data would only be included if there was an independently reached consensus. Zbys Fedorowicz held the master copy of the review.

The following details were to be extracted.
(1) Study methods: method of allocation, masking of participants and outcomes, exclusion of participants after randomization and proportion of follow-up losses;
(2) Participants: country of origin of the study, sample size, age, gender, inclusion and exclusion criteria;
(3) Intervention: duration and length of time in follow-up;
(4) Control: either of the two interventions used as a control;
(5) Outcomes: as described in the section on outcome measures.
therefore no data were available.

controlled trials were found for this review and Figure 1. In summary, no relevant randomized
criteria and were excluded from the present review.
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were not within the scope of this review.1-3. This
patients. Many of the trials that were examined in this
and report not only clinically relevant outcomes,
but also those that are of importance to patients.
advancement in endodontics, and its apparent
superiority for primary instrumentation of root
canals does not appear to have been confirmed in
these trials.
Many of the limitations, as well as some of the
possible applications, of ultrasonic instrumentation
used alone for root canal treatment are well
recognized, but there appears to be a need for
further research that focuses on ways in which these
applications, in particular improved debridement in
less accessible canals, can be used as an adjunct
to hand instrumentation.
The results of this systematic review confirm
that future research should include more in vivo
trials with outcomes that are patient-centered as
listed in the primary outcomes for this review, and
trials that are robust, well designed and reported
according to the CONSORT statement (available
from http://www.consortstatement.org/).

Sucessful endodontic treatment is largely
dependent on the complete removal of all necrotic
tissue remnants and on the overall reduction in
number of bacterial organisms in the root canal.
Careful preparation, shaping and subsequent
obturation of the root canal are essential steps in
the process.
However, due to the complex nature and
irregularity of root canal anatomy, the process of
cleaning and shaping can be very time consuming
and laborious. Although ultrasonic instrumentation
for root canal treatment would appear to offer
several advantages over the traditional method
of hand instrumentation, the use of ultrasonically
driven instruments has not been universally
accepted.
The majority of studies that were examined had
been conducted on extracted teeth, and the only
retrieved clinical trials comparing ultrasonic and
hand instrumentation had assessed issues that
were not within the scope of this review.1-3. This
noticeable absence of trials highlights the need for
investigators in future trials to ensure they identify
and report not only clinically relevant outcomes,
but also those that are of importance to patients.

This information was to be used to help assessing
the heterogeneity and the external validity of the
trials.

Findings
The search strategy retrieved 226 (7 Cochrane
Oral Health Group Trials Register, 12 CENTRAL, 8
EMBASE, 192 MEDLINE, 7 LILACS) references to
studies, which were independently assessed for
relevance by three of the review authors (Patrick
Sequeira, Zbys Fedorowicz and Jeronimo Manço de
Oliveira Neto). Only 10 references1,2,3,4,8,9,13,17,21,22
were considered for further analysis.

Full-text reprints of these 10 remaining studies
were obtained. Their reference lists were examined,
but they did not provide any additional citations to
potentially eligible studies. We arranged to translate
the studies that were written in Chinese, Italian,
Russian and the Japanese languages. None of
the retrieved studies, however, met our inclusion
criteria and were excluded from the present review.
The reasons for their exclusion were noted. See
Figure 1. In summary, no relevant randomized
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DISCUSSION

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<table>
<thead>
<tr>
<th>Study</th>
<th>Reason for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burleson11 (2007)</td>
<td>The trial did not evaluate any of the primary or secondary outcomes of this review</td>
</tr>
<tr>
<td>Carlii (1989)</td>
<td>In vitro study</td>
</tr>
<tr>
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<tr>
<td>Chan3 (1990)</td>
<td>In vitro study</td>
</tr>
<tr>
<td>Hong4 (1998)</td>
<td>Non-randomized study</td>
</tr>
<tr>
<td>Ishikawa3 (1988)</td>
<td>Non-randomized study</td>
</tr>
<tr>
<td>Makeeva13 (2005)</td>
<td>In vitro study</td>
</tr>
<tr>
<td>Palazzo17 (1989)</td>
<td>Review. Non-clinical study</td>
</tr>
<tr>
<td>Wu21 (1993)</td>
<td>Comparison of canal irrigants</td>
</tr>
<tr>
<td>Xiong23 (2001)</td>
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</tbody>
</table>

Figure 1- Characteristics of excluded studies

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investigators in future trials to ensure they identify
and report not only clinically relevant outcomes,
but also those that are of importance to patients.
Many of the trials that were examined in this
review compared the cutting efficiency and other
characteristics of hand files with ultrasonically
activated files, and the most frequently reported
outcomes were expressed as debris indices, sterility
and bacterial counts and overall cleanliness of
prepared canals. However, the general perception of
ultrasonic instrumentation as a major technological
advancement in endodontics, and its apparent
superiority for primary instrumentation of root
canals does not appear to have been confirmed in
these trials.
Many of the limitations, as well as some of the
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CONCLUSIONS

This review illustrates the current lack of published or ongoing randomized controlled trials and the unavailability of high-level evidence based on clinically relevant outcomes referring to the effectiveness of ultrasonic instrumentation used alone or as an adjunct to hand instrumentation for orthograde root canal treatment. In the absence of reliable research-based evidence, clinicians should base their decisions on clinical experience, individual circumstances and in conjunction with patients’ preferences where appropriate. Future randomized controlled trials might focus more closely on evaluating the effectiveness of combinations of these interventions with an emphasis on not only clinically relevant, but also patient-centered outcomes.

ACKNOWLEDGEMENTS

We would like to acknowledge the contribution of Luisa Fernandez Mauleffinchi, the Cochrane Oral Health Review Group Coordinator, Vasily Vlassov who kindly translated one of the studies from the Russian into the English language, and the referees who commented on this review. This paper is based on a Cochrane review published in Issue 4, October 2008 of The Cochrane Library. Cochrane reviews are regularly updated as new evidence emerges and in response to comments and criticisms, The Cochrane Library should be consulted for the most recent version of this review (available from http://www.cochrane.org).

REFERENCES