

## Systematic review

# Surgically facilitated experimental movement of teeth: systematic review

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## Abstract

Several surgical techniques based on corticotomy and dental distraction have been developed to improve the movement of teeth and reduce the duration of orthodontic treatment. In this systematic review we have critically assessed published studies on the experimental movement of teeth to find out whether operations such as corticotomy and dental distraction osteogenesis increase the rate of movement, and to find out which biological mechanisms are engaged during surgically facilitated orthodontics, and which complications may be seen. We searched PubMed and Embase for publications until January 2014 and screened the titles and abstracts. Articles that met the inclusion criteria were retrieved in full and assessed independently by 2 of the authors. A total of 22 studies were included, and corticotomy and distraction techniques were the main surgical methods. Generally, all studies reported that movement of teeth was faster after operation than with conventional orthodontics. The peak velocity was always at an early postoperative stage regardless of the surgical technique used. Immunohistological data showed simultaneous regional increases in catabolic and anabolic activity. Histomorphometric data showed more direct resorption of bone and less hyalinisation after operation, and a reduced bone volume density around the surgical site. When present, complications such as root resorption or periodontal problems were minimal. Current experimental animal studies show that procedures such as corticotomy and dental distraction can accelerate the movement of teeth without severe complications because of the regional increase in catabolic and anabolic remodelling.

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## Introduction

Orthodontic treatment aims to improve dentofacial function and aesthetics but patients often complain that it takes a long time to achieve optimal results. To overcome this, surgical techniques have been developed,<sup>1,2</sup> and 2 approaches have been reported to facilitate the movement

of teeth. The first is corticotomy in which cortical bone is cut to improve bony remodelling. Periodontally accelerated osteogenic orthodontics, which is a combination of selective alveolar decortications and alveolar augmentation,<sup>3–5</sup> can be modified using selective piezosurgery to circumscribe the roots,<sup>6</sup> and more recently, techniques for minimally invasive flapless corticotomy have been introduced.<sup>1,2</sup>

The second approach is based on distraction osteogenesis, a method described by Ilizarov to induce new bone to form by the mechanical stretching of pre-existing bone.<sup>7</sup> Liou and Huang first applied the concept to the periodontal ligament to facilitate rapid canine retraction in premolar extractions.<sup>8</sup> Kharkar et al. and Işeri et al. described dentoalveolar distraction, which involves decortications around the canines,

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removal of the buccal plate and lining of the extraction socket, and mobilisation of the bone block that contains the canine, to achieve rapid retraction.<sup>9–11</sup> Another more invasive procedure is osteotomy distraction, which involves cutting through the cortical and trabecular bone to create a completely separate alveolar segment, followed by application of a continuous distraction force to create a distraction site in the bone.<sup>11</sup>

Both corticotomy-facilitated orthodontics and distraction techniques temporarily improved the movement of teeth with minimal or no complications.<sup>1,3,4,6</sup> Several authors have reported that corticotomy reduced the overall treatment time by between 28% and 70%, and that distraction osteogenesis reduced it by up to 50%.<sup>6,10–12</sup> Canine retraction was achieved within 2 weeks with dentoalveolar distraction and within 3 weeks with distraction of the periodontal ligament, and with both there was minimal loss of anchorage.<sup>8,10,11</sup> Authors of a recent systematic review on human subjects concluded that based on available evidence, surgically facilitated orthodontics seems to shorten treatment time effectively and safely.<sup>13</sup> However, they noted that the level of evidence was limited because of shortcomings in the methodology of the studies included.

Experimental studies can help to overcome some of the limitations of clinical research, and can refine the organisation of clinical studies. Large sample sizes, well-controlled reference groups, and better homogeneity and reproducibility are possible in animal experiments.<sup>14–18</sup> One of the main advantages is that they allow biological mechanisms that underlie improvements in the movement of teeth to be investigated histologically or by micro-computed tomography (CT), or both.<sup>19–21</sup>

Several experimental studies have shown that operations can accelerate the movement of teeth,<sup>14,16,17,22</sup> and histological or immunohistochemical data, or both, have shown regional increases in catabolic and anabolic remodelling with the peak at 1–3 weeks after surgically induced trauma.<sup>19–21</sup> To our knowledge, these studies have not been systematically evaluated and compared.

The aim of this review was to assess published animal studies critically to find out whether operations such as corticotomy and dental distraction osteogenesis significantly increase the movement of teeth. We also aimed to establish the biological mechanisms that are engaged during surgically facilitated orthodontics and to find out which complications may be seen.

## Material and methods

### Selection criteria

This systematic review was based on the PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines.<sup>23</sup> Studies on animals that included operations and velocity of tooth movement or histological analysis were

included. Those that described only operations and protocols, or pharmacologically accelerated movement of teeth, or were in languages other than English, German, or Dutch, were excluded.

### Information sources

We searched PubMed and Embase for work published until January 2014 using the following keywords rapid tooth movement; corticotomy and orthodontics; corticotomy-facilitated orthodontics; accelerated tooth movement; dentoalveolar distraction; distraction and orthodontics; periodontal distraction and orthodontics; and regional accelerated phenomenon, and orthodontics accelerated osteogenic orthodontics. All eligible studies were checked manually for additional references.

### Data extraction

To identify relevant articles, we screened titles and abstracts, and retrieved the full text of papers that met the inclusion criteria. They were then assessed independently for eligibility by 2 authors (AL/YR), and disagreements were resolved by discussion until consensus was reached. Data collection forms were used to compile and present the outcomes of the reviews. Data were collected on the type of operation, number of animals, type of tooth, internal or external control group, and orthodontic force used; and on the frequency of reactivations, rate of tooth movement, incidence of complications, and (immuno)histological or micro-CT outcomes, or both.

### Grading of studies

We evaluated the methods used in the studies according to the National Centre for the Replacement, Refinement, and Reduction of Animals in Research (NC3Rs) survey of experimental design and reporting, which is based on the Animal Research: Reporting of In Vivo Experiments (ARRIVE) guidelines.<sup>24,25</sup> This consists of a checklist of essential information that should be included in all experimental studies, and we graded the articles into 3 categories based on the number of items they contained: three-quarters (A), half (B), and a quarter (C). Potential bias was assessed using the Cochrane Collaboration's risk of bias tool.<sup>26</sup> Case studies without controls were not assessed with this tool because the risk of bias is inherently high.

## Results

### Studies

Our initial searches yielded 154 studies: 94 from PubMed, 58 from Embase, and 2 from hand searches (Fig. 1). After initial application of the exclusion criteria and elimination of duplicates, 137 publications were retrieved. When the full texts were assessed according to the inclusion criteria, 31

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