Accelerated Orthodontic Tooth Movement Following Le Fort I Osteotomy in a Rodent Model

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Purpose: In surgery-first accelerated orthognathic surgery, the clinical phenomenon of accelerated orthodontic tooth movement after osteotomy is a benefit compared with the conventional approach. However, because much of the literature on this phenomenon is based on empirical evidence and case reports, experimental animal-based studies are needed to verify and quantify this acceleration effect. The purpose of this prospective experimental study was to identify whether osteotomy procedures increase tooth movement.

Material and Methods: Le Fort I osteotomies were performed on the left maxillas in 15 male adult Sprague-Dawley rats. After surgery, a continuous force of 0.5 N was placed on the maxillary left first molar to move the tooth mesially. Another 15 rats had no surgery and served as controls. On days 1, 14, and 28, digital caliper measurements were taken to record tooth movement.

Results: In the experimental group, the maxillary left first molars moved significantly more rapidly on days 14 and 28 ($P < .05$). Histologic findings showed more active alveolar bone remodeling.

Conclusion: Le Fort I osteotomy significantly accelerated the rate of orthodontic tooth movement. Histologically, more active and extensive bone remodeling was observed after osteotomy.

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Recently, surgical plus orthodontic treatment without preoperative orthodontic treatment (known as the surgery-first approach [SFA]) has been proposed as advantageous.[1,2] Compared with a conventional approach, a patient's lateral profile and occlusion can be improved significantly at the beginning of the treatment course. More importantly, in most reported cases, patients treated with the SFA required shorter orthodontic treatments than those who underwent the conventional approach. Postoperative orthodontic alignment and anteroposterior, vertical, and transverse orthodontic tooth movements can be achieved more easily and faster, within approximately 3 to 4 months after the initial surgery.[3,4] Some investigators have suggested that surgeries, including Le Fort I osteotomies or bilateral sagittal split osteotomies (BSSO), can trigger a 3- to 4-month postoperative period of greater osteoclastic activities and metabolic changes in the dentoalveolus and facilitate tooth movement. However, no experimental study has been conducted to identify

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this clinical phenomenon. In the present study, a rodent model was used to test whether Le Fort I osteotomy could increase the velocity of postoperative tooth movement.

Material and Methods

This study used 30 adult male Sprague-Dawley rats obtained from the Laboratory of Animal Science Center of Shanghai Ninth Hospital (Shanghai, China). The study protocol was reviewed and approved by the institutional animal use and care committee. All animals were housed at the Laboratory of Animal Science Center, where all procedures, including surgery, orthodontic appliance application, and euthanasia, were performed. Animals' health status was evaluated daily and no significant fluctuation or differences were observed between groups during the experimental period. Each cage housed a maximum of 3 rats, with diet and water provided ad libitum. A 12-hour light and 12-hour dark cycle was maintained during the experimental period. All rats were 90 days of age and had a body weight ranging from 300 to 400 g (average body weight, 335 g). They were randomly divided into an experimental group and a control group of 15 animals each.

In the experimental group, the following surgical procedures were performed:

1. Each animal was anesthetized with intraperitoneally injected chloral hydrate at a dosage of 400 mg/kg.
2. A horizontal intraoral incision of the mucosa was made along the buccal vestibule of the maxilla from the incisor to the third molar. A mucoperiosteal flap was reflected to expose the site of the osteotomy on the buccal side.
3. After exposure of the labial bone surface and infraorbital nerve, Piezosurgery was used for Le Fort I osteotomy with saline irrigation. At the level exactly beneath the infraorbital nerve, 1 horizontal osteotomy line was made from the zygomatic alveolar ridge to the paranasal region (Fig 1). The osteotomy line was 5 mm from the apex of the molars.
4. After osteotomy, a mini bone chisel was inserted into the osteotomy line to pry the bone block loose. The process was performed carefully to avoid unfavorable fracture.

After the surgical procedures, the following orthodontic appliances were attached to all animals in the experimental and control groups:

1. A 0.020-inch stainless steel ligature wire was bent to enclose the left maxillary first molar at the cervical margin.

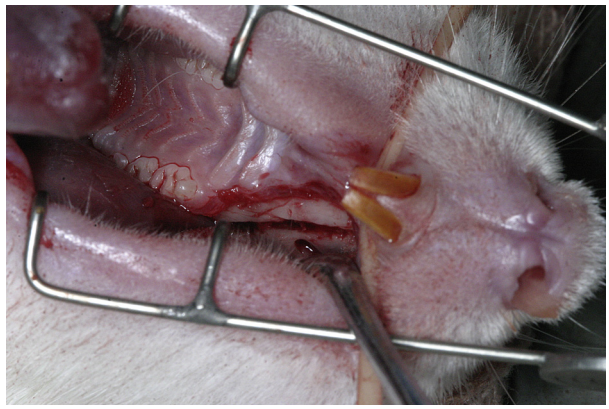

FIGURE 1. Photograph of Le Fort I osteotomy in the left maxilla.

Yuan et al. Orthodontic Movement After Le Fort I Osteotomy. J Oral Maxillofac Surg 2014.

2. A horizontal cervical groove was made encircling the left maxillary incisor using a 0.5-mm round bur on a low-speed micromotor. Another ligature wire was tightened around the groove.
3. A nickel-titanium closed-coil spring was attached to these ligature wires and stretched between the incisor and the first molar. The spring was proved to deliver a continuous force of 50 cN to induce mesial tooth movement of the first molar (Fig 2).

To measure tooth movement, the distance between the distal surface of the first molar and the mesial surface of the second molar was recorded on days 1, 14, and 28 using a digital caliper (Endura, Shanghai, China). The measuring jaws of the digital caliper were placed exactly at the borders of the gap. The measurements were made to the nearest 0.01 mm (Fig 3). All measurements were performed by 1 specialized observer; every distance was measured 3 times and the average was used. Intergroup differences in tooth movement on days 1, 14, and 28 were

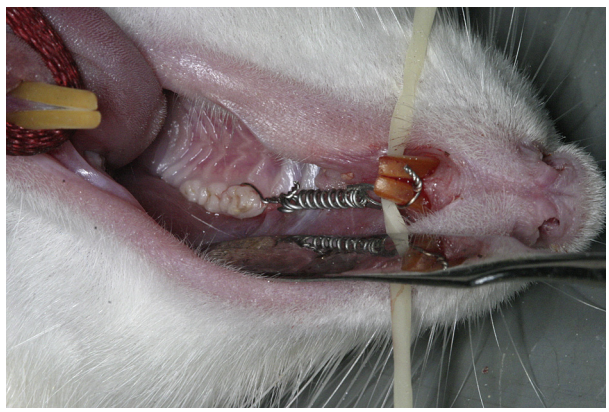

FIGURE 2. Photograph of orthodontic appliances used for tooth movement.

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