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A comparative study of internal fixation and intermaxillary fixation on bone repair of mandibular fractures through radiographic subtraction

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ABSTRACT

Conventional radiographic evaluation of fracture healing is not a reliable method, because it depends on the examinator's experience and the quality of the exam. Therefore, serial images differing in density, contrast and geometrical projection can lead to a misdiagnosis on the postoperative fracture healing. Even in good quality images, little changes in calcified tissues often can't be visualized, because of its little sensibility and because of the limited human sight. The use of more sensitive and objective methods could increase the accuracy of this evaluation. This study intended to compare, by digitalized panoramic radiography, the mandible fracture healing after two different types of treatment: open reduction with internal fixation (group 1) and closed reduction with intermaxillary fixation (group 2). It was taken three postoperative radiographs (within a week, a month and three months after treatment), which were digitalized (600 dpi, 8 bits) and adjusted in brightness and size in Photoshop® software. Then these images were evaluated by digital subtraction in ImageTool® software. The results revealed greater areas of new bone formation in the internal fixation group, in all the evaluated times. Thus, open reduction with internal fixation resulted in more rapid fracture healing than closed reduction with intermaxillary fixation.

1. Introduction

Mandibular fractures can be treated conservatively by closed reduction and intermaxillary fixation, or invasively by means of open reduction and internal fixation (Chrcanovic et al., 2004; Ghazal et al., 2004; Brasileiro and Passeri, 2006). These techniques differ regarding the patient's comfort, cost, time, surgical technique, as well as the quality of bone reduction and risk of infection (Moreno et al., 2000; Schmidt et al., 2000; Lamphier et al., 2003; Shetty et al., 2003; Stacey et al., 2006).

Radiological images are important tools in making mandible fracture diagnosis and helping to characterize post-treatment complications and establish the procedures needed (Yamamoto et al., 2013). Intraoperative analysis using a cone-beam tomography has been reported as a helpful way for real-time assessment of mandibular fracture reduction in minimally invasive surgical techniques (Klatt et al., 2012).

The analysis by radiographic subtraction uses serial images in an equivalent geometric contrast and density, which enables the perception of subtle alterations (Ribeiro and Feitosa, 1999; Tsiklakis et al., 2005). This type of analysis can indicate the degree of bone healing in a mandibular fracture site more objectively, allowing researchers and healthcare providers to compare the two forms of treatment more accurately (Villarreal et al., 2000).

Imaging studies that assess the bone healing of these fractures after treatment with either approach are uncommon (Kawai et al., 1997; Villarreal et al., 2000). The objective of this study is to compare the internal fixation and intermaxillary fixation on bone healing of mandibular fractures through radiographic subtraction.

2. Materials and methods

The study included patients with mandibular fractures who presented to the Department of Maxillofacial Surgery at Santo

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Antonio Hospital (Sister Dulce Social Works) and Edgard Santos University Hospital (Federal University of Bahia) from April 2005 to July 2006.

Subjects were divided into two groups: a) Group 1: open reduction with internal fixation and b) Group 2: closed reduction with intermaxillary fixation.

Exclusion criteria of the sample were subjects younger than eighteen years; systemic disease or use of drugs that might interfere with bone metabolism; smoking, alcohol, or illicit drug use; postoperative infection; healed fractures; symphyseal and condylar fractures; impossibility of adequate intermaxillary fixation; fractures that required reintervention.

The study design was approved by the Ethics Committee of the Faculty of Dentistry (Federal University of Bahia) and all participants agreed to be part of it, signing the Instrument of Consent prepared for this purpose. All terms of this study are consistent with the ethical standards required (Resolution MS/CNS 196/96, which deals with research on human subjects).

2.1. Surgical procedure

Patients in group 1 were operated upon under general anesthesia, and access to and fixation of fractures was performed in accordance with the judgment and experience of each surgeon. Intermaxillary fixation with Erich bars was used in the transoperative phase and for the first two weeks after surgery.

In group 2, conservative treatment was performed with intermaxillary fixation that continued for six weeks, using Erich bars and steel wire (Aciflex n° 1) placed under local anesthesia in an outpatient setting.

2.2. Image evaluation

In each patient, three panoramic radiographs were obtained at different postoperative times: T1 – up to seven days; T2 – thirty days; T3 – ninety days.

Panoramic radiography was performed in a standardized way (radiographic equipment *Rotograph Plus – Villa Sistemi Medicali, Milano – Italy*), with 10 mA and 17 s of exposure. The kV was selected depending on the patient size, ranging from 60 to 90 kV. The radiographic film (T-MAT G – 12 × 30 cm – *Kodak Company, New York, USA*) was used in conjunction with enhancers plates (Lanex Regular – *Kodak Company, New York, USA*) and stored in a specific cassette for the radiographic equipment. The patient was suitably protected with lead vest (0.5 cm thick) during radiographic exposure. After exposure, the films were developed by the temperature–time method in a standardized way, in an appropriated environment and with fresh processing solutions (GBX – *Kodak Company, New York, USA*). The processing took place in a dark chamber, dark room type, containing an appropriate safety lamp with GBX-2 filter (*Kodak Company, New York, USA*). Radiographs were dried in an appropriated hothouse and, as soon as ready, properly identified with self-adhesive labels. All radiographs of all patients were performed in the same equipment, in the Department of Radiology, Dentistry School of Federal University of Bahia.

The radiographs were scanned (Laser Scanner HP PrecisionScan Pro 2.5, ScanJet XPA, Hewlett Packard Company, Greeley, Colorado, USA), digitized (600 dpi, 8 bits), and saved in .bmp format.

The images were opened in Photoshop (Adobe Systems Incorporated, Mountain View, California, USA) in which the three radiographs taken for each patient were adjusted for brightness, taking as reference the cortical bone of the lower edge of the mandible. To that end, we designed a rectangle (using the "rectangular marquee" tool) in this cortical area, so that the rectangle did not differ much in number of pixels in the three radiographs. These areas contained between 3,000 and 7,000 pixels and accepted a difference of up to 300 pixels from the radiographs of the same patient. The size of this rectangle was measured using the "histogram" tool, which also indicated the average gray value of each area. This average was measured in each of the three patient images; one of the values was picked up and replayed for the other two images, using the "brightness adjustment" tool and saving it again. When the difference between the average gray levels of the rectangle was rated five, the brightness adjustment was disregarded.

After the images were cut, using the "cropping" tool, from specific anatomical landmarks, the number of pixels in the width and height of each image was evaluated (using the "image size" tool) to ensure the images were equal in size. After all images were equated, the images were saved once again. To ensure the equal size of the series of images, evaluating the number of pixels in width and height (using the tool "image size"), equating it throughout the series and saving the images again.

After being adjusted in brightness and size, the images were opened in the ImageTool program (University of Texas Health Science Center, San Antonio, Texas, USA) and images were evaluated. All evaluations were performed by a single examiner who viewed the images in a 15″ Super VGA flat-screen monitor with medium gloss intensity. The distance between the examiner and the monitor was about 60 cm. The analysis sessions did not exceed 4 h.

2.3. Analysis by radiographic subtraction

We used the corresponding tool and the program electronically subtracted images in the following order: T1 – T3, T3 – T2 and T1 – T2. The subtracted images were copied and saved in a PowerPoint file (Microsoft™ – USA), in which the examiner indicated whether there was bone resorption or new bone formation, or even the presence of these two events simultaneously in the fractured regions, between the times studied (Figs. 1 and 2).

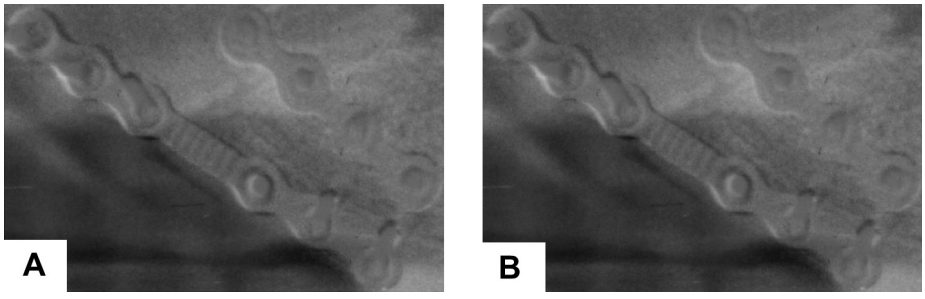

Fig. 1. Group 1 subtracted images. In A, the result of the second radiograph subtracted from the first, with sharp bone formation in the fracture line. In B, the result of the third radiograph subtracted from the first, with the persistence of bone formation.