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Changes in the inferior alveolar nerve following sagittal split ramus osteotomy in monkeys: A comparison of monocortical and bicortical fixation

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Abstract

We aimed to observe the changes in the inferior alveolar nerve (IAN) after bilateral sagittal split ramus osteotomy (SSRO) using monocortical or bicortical screw fixation. Bilateral SSRO for setback of the mandible was done in 12 monkeys, and monocortical or bicortical fixation was applied on opposing sides of each mandible. Sensory nerve action potentials were tested before and immediately after operation, and at 2, 4, 8, and 12 weeks. Six animals selected randomly were killed at 4 and 12 weeks after the operation. Specimens of nerve were harvested and processed for histological examination and electron microscopic analysis. Obvious prolongation of latency and diminution of amplitude in the IAN were found postoperatively. At 4 weeks after operation, Wallerian degeneration was apparent, and there were signs of axonal regeneration in the nerves. The IAN had more abnormalities of evoked potentials and pathological changes after bicortical than after monocortical fixation. Although considerable recovery was found after both forms of fixation at 12 weeks, the function of the nerve after plate fixation was better than after screw fixation. Our results suggest that the nerve damage during SSRO could be temporary and reversible, and monocortical fixation may result in restoration of the nerve function sooner than bicortical fixation.

Keywords: Sagittal split ramus osteotomy; Inferior alveolar nerve; Monocortical fixation; Bicortical fixation; Rhesus

Introduction

Since the introduction of sagittal split ramus osteotomy (SSRO) by Trauner and Obwegeser in 1957,[1] it has become the most popular way of correcting deformities of the lower jaw. However, clinical investigations have shown a high incidence (40–85%) of neurosensory deficits associated with SSRO.[2–4] Although these may involve traction on the inferior alveolar nerve (IAN) during operation, and direct injury to the nerve when the ramus is split and the screw holes are drilled, compression of the bony segments on the IAN as a result of rigid fixation could be correlated with postoperative neurosensory disturbance. Paraesthesia may develop even when the nerve remains visibly intact during operation, and it is generally thought to be caused by mechanical damage to the sensory fibres of the IAN.[5,6]

A number of clinical investigations have reported neurosensory deficits after SSRO associated with the use of various fixation techniques,[2,4,7,8] but we know of few animal studies that have examined the function and structure of the nerves. Skeletal class III malocclusion is a common dentofacial deformity among Asian people. In contrast to the vertical ramus osteotomy, SSRO has been used more often for correction of a prognathic mandible.

This study was designed to see what changes developed in the IAN after setback of the mandible by SSRO using fixation by monocortical or bicortical screws in rhesus monkeys.

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Material and methods

Animals

Twelve adult male rhesus monkeys (4.5–6-years-old) weighing 8–10 kg were used. Their care was in accordance with the guidelines by the Animal Centre for Medical Experiment at the University.

Preoerative protocol

According to the method described by Ellis et al.,[9] the upper and lower anterior teeth were extracted under anaesthesia 4 weeks before SSRO. This was necessary to facilitate the setback of the mandible and feeding. The upper and lower dental impressions were taken after extraction of the teeth. The dental models were prepared and articulated. We made a model of the mandibular setback of two molar cusps (approximately 5–6 mm). An acrylic interocclusal splint was then fabricated to lock the remaining teeth into the new position.

Surgical procedures

The monkeys were premedicated with ketamine hydrochloride (10 mg/kg intramuscularly), intubated endotracheally and anaesthetised with sodium pentobarbitone intravenously. SSRO for setback of the mandible, which was similar to the method described by Lupori et al.,[10] was done intraorally in all monkeys.

After segregation of the proximal and distal segments, the mandible was moved backwards and placed in the planned occlusion using the interocclusal wafer and maxillomandibular fixation. The size of the mandibular setback for all animals was 5–6 mm. Extreme caution was taken to avoid direct injury to the IAN bundle during the procedures, and the nerves of all animals were intact and on the distal segments after SSRO. On the right side, a miniplate and four titanium screws (6 mm long) were used for monocortical osteosynthesis between the proximal and distal segments. On the left side, the proximal and distal segments were secured with two bicortical positional screws (12 mm long). The screws were inserted above the IAN bundle, and the gap between bony segments was closed completely after rigid fixation with screws. A senior surgeon did all the operations with the same surgical instruments. Maxillomandibular fixation was applied with wires for 1 week.

Electrophysiological monitoring

The function of the IAN was assessed by testing the sensory nerve action potential (SNAP). An eight-channel electromyography system (MEB-2200 Nihon Konhden, Japan) was used to evoke the action potential recording. Electrophysiological testing was similar to the methods described in a previous study.[11] The SNAPs of the IAN on both sides were monitored before, and immediately after, operation, and at 2, 4, 8, and 12 weeks. The values obtained before operation were taken as baseline and set as 100%, and data taken postoperatively were calculated as a percentage of this baseline for analysis of the change in latency and amplitude of evoked potentials. The changes in the latency and amplitude from one time point to the next, and the differences between two sides were compared by Student's paired *t*-test and probabilities of less than 0.05 were accepted as significant.

Harvesting and processing samples of nerve

Under general anaesthesia, six animals selected randomly were killed at 4 and 12 weeks postoperatively. The segments of the IAN in the callus of the bone at the mandibular split areas were carefully dissected and removed. Each segment (10 mm long) was stabilised on a cork board to maintain its length and fixed in 2.5% glutaraldehyde in phosphate buffer for 12 h at 4 °C. The nerve was then washed in phosphate-buffered saline, dehydrated in ethanol, and embedded in epoxy resin. Semithin sections (1 μm) were obtained from three sites (proximal, middle, and distal) along the segment of each nerve. One of five sections from each site was chosen at random and stained with toluidine blue for examination under light microscopy. Additionally, ultrathin sections were cut, stained with lead citrate and uranylacetate, and examined in a transmission electron microscope (JEM-100SX, Jeol Ltd., Japan).

In addition to general histological evaluation, the semithin sections were examined histomorphometrically by a computer system using the OPTMAS 6.0-image 2 software (Media Cybernetics, Silver Spring, MD, USA). Axons were counted in 15 fields of 40 μm × 40 μm from three sections (proximal, middle, and distal) of each specimen. Data from each group and each time point were averaged and the significance of differences compared and assessed using the Student's *t*-test.

Two additional monkeys of similar age and weight but not operated on were used as normal controls; their bilateral IAN were harvested from the mandible and prepared in the same manner.

Results

Clinical findings

All animals tolerated the operations well. The mandibles had healed perfectly by the time that they were killed, and the specimens of IAN were intact with no signs of direct injury (Fig. 1).

Neurosensory functions

The mean (S.D.) of the changes in latency and amplitude of the IAN evoked potentials before and after operation are shown in Table 1 and Fig. 2. There were no significant