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Establishment of Mandibular Fracture Model in Rats

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Abstract

In clinical practice, jaw fracture is a common disease, and the main causes of such fractures are traffic accidents, sports, and percussion injuries. Due to its special location, the jaw bone often requires more targeted and efficient treatment. Therefore, the establishment of scientific jaw fracture models is very important in the study of the mechanism of jaw fracture healing process. In this paper, we describe in detail several modeling approaches for rat mandibular fractures, analyze their advantages and disadvantages, and provide an experimental reference basis for the construction of basic experimental research models.

Keywords

Rat; Jaw Fracture; Model.

1. Introduction

The jaw fracture is a common disease clinically, usually the treatment is to achieve the ideal effect by surgical means, the incidence of this disease is high in young people, the main causes of such fractures are traffic accidents, sports, percussion injuries, etc., due to the particularity of the mouth position, maxillofacial fractures have features which are obviously different from fractures in other parts of the body. This part has frequent activities and complex muscle attachment; the structure has particularity, it is connected to the traumatic brain above and the cervical vertebrae below, and it is more difficult to treat. [1] It also affects the appearance of the patient, beauty is an important factor affecting the psychology of the patient, so the repair requirements are higher. Since the force loading and development of the mandible is very different from that of the long bones, moreover, the microenvironment of the mandible is different from that of the long bone and skull bone, the existence of teeth also increases the necessity of the existence of a mandibular fracture model, so a single ideal mandibular fracture model is urgently needed.

Rats are widely used in the establishment of experimental models due to their high quality and value for money, strong repeatability, good learning curve, easy feeding, and low social attention, etc., and are also widely used in bone tissue engineering. The relevant report on the rat mandibular fracture model is as follows [2].

2. Advantages and Limitations of the Mandibular Fracture Rat Model

1) The rat and human genomes are higher in homology. The evolutionary differences between rat and human are small, judging from the genome, rat has 2.75 billion genomes and human has 2.9 billion genomes, they are relatively close; in chromosomes, rat has 21 chromosomes, which are closer to human 23 chromosomes, and for the part of the mandible, the muscle attachments of rat and human are similar. Therefore, it is relatively more meaningful to deduce the research carried out in rat to human.

2) Model construction is convenient and fast. Compared with large animals such as beagle dog, rabbit and primates, the economic cost of is lower, management requirements are lower, and purchase and maintenance costs are lower. [3] Rat is easy to raise, has strong self-resistance such as anti-infection,

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has a high survival rate, and when the composite disease model is required, due to more research on rats, the establishment of models is more direct and supported by many documents, which can provide more favorable conditions for experiments.

3) The volume of the mandible of rat is smaller, it is horseshoe-shaped, irregular in shape, and is interfered with teeth, as a result, the part that can be manipulated of mandible is smaller. Due to the particularity of its position, the fixation and stabilization effects of this part are poor, and it is difficult to fix it, so the requirements for model establishment are high, and the requirements for technical accuracy are also higher.

3. Establishment of Mandibular Fracture Model

Since the mandible of rat is smaller, at present, there is no ideal mandibular fracture model which get extensive consensus, the mandibular fracture models established by many scholars are mainly two categories: one is open fractures, and the other is closed fractures. Open fractures are divided into various methods based on the fracture position, the used tools and whether they are fixed or not.

3.1 Open Fracture

Open fractures make fracture ends connect with the outside world, and the skin and subcutaneous soft tissues covering the fracture position are broken. The open mandibular fracture model usually is that rat is placed in the supine position after general anesthesia, under sterile conditions, a linear incision is made at the lower edge of the mandible to expose the lower edge of the mandible and the buccolingual surface of the mandible. The soft tissue is sharply dissected to expose the mandible, then the relevant tools are used, the appropriate position and angle are selected to build a smooth bone surface cut as the fracture model, after the fracture is caused, the appropriate fixation method or non-fixation can be selected upon request [4].

3.1.1 Construction of Open Fractures with Dental Handpiece

Mohammad Zandi et al.[5] took 120 six-month-old male Wistar rats, weighing 350±25g, and made 15mm-long linear incision parallel to the lower edge of the mandible, after exposing the mandible, carried out the vertical osteotomy 5mm behind the last molar, used the high-speed handpiece in combination with 0.5mm fissure bur to complete the osteotomy under the irrigation of a large amount of normal saline, after checked the condition of the fracture segment, contacted the proximal and distal bone ends and fixed with stainless steel wire, after layered suture, gave antibiotics and analgesics for 7 consecutive days, gave appropriate basic car, most newly formed bone trabeculae in the fracture gap had been replaced by mature bone 30 days after the operation, but bone remodeling was still in progress. However, stainless steel wire fixation was relatively easy to loosen and break, and it was also easy to cause damage to the periosteal blood supply, resulting in the absorption of compressed bone and affecting the healing of fractures.

Cihan Bereket et al.[6] took twenty 12-week-old female SD rats, weighing about 250 g, made 2 cm long incision along the lower edge of the mandible, and exposed the mandible by blunt dissection, used fissure bur with 1mm diameter carry out vertical cortical incision, extending from the teeth to the lower edge of the mandible, and installed titanium plates and screws, the titanium plate was the customized small 4-hole plate, after being tightly fixed, completed the fracture line with a chisel, stitched in layers, and gave antibiotics. New bone tissue and connective tissue were observed by micro-CT 21 days after operation. This operation requires the customization of titanium plate and nails, due to the small volume of the rat mandible, although the retention and stability can be guaranteed, it is difficult to operate, and the customized titanium plate and nails are expensive.

Mohammad Zandi et al. [7] and others took fifty 5-month-old female Wistar rats, weighing about 330g. After the CBCT was obtained, it was divided at the center joint of the mandible of the rat, due to the muscle attachments, there was no obvious displacement of the fracture, and the author did not fix it. This model is constructed without fixation, but the experiment found that there is malposition

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healing, and the fixation means should be added, however, due to the small volume and special shape of the rat mandible, if it is difficult to fix, this is not an ideal modeling means.

Yang Xueping et al. [8] took 144 Wistar male rats, weighing about 300g. Under sterile conditions, the low area of left jaw was incised to expose the lower edge and buccal-lingual side of the left mandible, and the dental grinding machine (1500r/s) was at the distal and middle ends of the masseter cristae at the inferior border of the mandible body, a neat bone defect with 3mm long and 1mm wide upwards from the lower edge of the mandible. This model is regarded as an incomplete fracture, which not only solves the problem of fixation of the fracture segment, but also reduces the difficulty of the experiment and accelerate the process of the experiment.

3.1.2 Construct Open Fractures with Sagittal Saw

Henry H. Rowshan et al. [9] took 29 male SD rats, weighing about 550-600g. Under general anesthesia, a 1-1.5 cm linear incision was made along the right submandibular inferior border under the operating microscope, after subperiosteal dissection, the sigmoid notch and the posterior border of the mandible were exposed. Two 5-hole plates were placed parallel to the sigmoid notch and fixed with four screws, approximately 4-5mm apart, passed the plate through the incision. The vertical osteotomy is then made from the sigmoid incision to the inferior border of the mandible with the sagittal saw. X-ray absorptiometry of the fracture position was carried out on the 7th and 21st days after the operation, it showed that the formation of new bone was obvious. This method can significantly reduce the probability of malposition healing, and the fixation strength is high, and it has little effect on the early open-mouth fasting of rats.

The methods of creating open mandibular fracture models are all the same, and the main difference lies in the position of the incision and whether it needs to be fixed. Open fractures have clear advantages, the operator can precisely control the position and angle of the fracture during the operation. The research shows that the position is mainly in front of the first molar, behind the last molar, and between the second and third molars. However, this operation method can easily bring about damage to the tooth root and cause persistent oral environment problems. Moreover, the trauma of open fractures is bigger, which significantly reduce blood circulation, and significantly prolong the healing time. In addition, the model structure is complex, labor is large, and the experiment is unstable. At present, there is no clear critical dimension to simulate the stable mandibular fracture.

3.2 Closed Fractures

Closed fractures is that fractured ends do not open with the outside world, and the skin and subcutaneous soft tissue covering the fracture position are intact. L. Rasubala et al. [10] took thirty 12-week-old Wistar male rats, weighing about 320-350 g. The right side of the mandible was fractured with the hemostatic forceps under general anesthesia, a large amount of new bone was seen 21 days after the operation, and the osteogenesis effect was good. Closed fractures are more convenient to operate, but since the angle of the fracture and the direction of the force line cannot be precisely controlled, it may cause different effects on the later detection, the comparison between the control group and the experimental group, and the healing of later fracture.

In conclusion, the author believes that an ideal mandibular fracture model should have the following features: (1) the fracture segment is stable and not displaced; (2) high repeatability; (3) clear standards and critical dimensions; (4) the operation effect is ideal, the morbidity and mortality of experimental animals are low, and the model establishment rate is high. In addition, the quality and value for money of experimental animals, feeding conditions, and acquisition is simple or not, all should also be considered. Restricted by the size of rats, it is difficult to apply too sophisticated and complex models to rats, and cannot be completely analogized to humans, which makes the establishment of this experimental model still have certain limitations. The parameters related to animal models are still controversial, as a result, the comparison of various indexes during the experiment is not clear, they will be disturbed with varying degrees. In order to make the evaluation of experimental objects clear and provide good experimental carriers for later experiments, the standardization of this animal model is an urgent problem to be solved.

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