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Difference Between Conventional Head-pin and Dispo-pin in the Sugita Multipurpose Head Frame System

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Abstract

Head fixation devices are commonly used in neurosurgical procedures and are considered essential tools for microneurosurgery. The Sugita multipurpose head frame system is one of such systems and has been used for more than 30 years worldwide. It is important to understand how to fix a patient's head with head-pins safely, because there are no numerical parameters for head-pin screwing in the Sugita frame. Recently, the Dispo-pin has been available for disposable use as a head-pin in the Sugita frame. In contrast to the conventional head-pin, the tip of the Dispo-pin is separable from the body. Although their appearance is similar, the torque for adequate fixation is different. The relationships between torque and vertical force were analyzed. The torque of the head-pin was linearly correlated with vertical force for both types of head-pin. Different conditions caused different torque increase against a specific increase of vertical force with the conventional head-pin. In contrast, torque increase against a specific increase of vertical force with the Dispo-pin was the same regardless of the situation. The torque originates from friction between the scalp and tip of the conventional head-pin. As friction is different for each patient's condition, the torque at this part is different. The friction between the tip and body of the Dispo-pin is lower than that between the scalp and tip of the head-pin. In consequence, the torque generated from the tip of the Dispo-pin is the same in each situation. It is important to understand the difference between the Dispo-pin and conventional head-pin.

Key words: head fixation, skull, head-pin, neurosurgery, torque

Introduction

The use of head fixation devices is a common part of neurosurgical procedures. Rigid head fixation is one of the most important factors for carrying out safe microneurosurgical procedures. Correct fixation of the skull using head-pins must be clearly understood. Excess screwing of head-pins may cause skull fracture and penetration, brain contusion, and intracranial hemorrhage.[1,2,9] On the other hand, inadequately weak fixation may allow dislodgement of the patient's head during surgery. The Mayfield skull clamp (Integra NeuroSciences, Plainsboro, New Jersey, USA) head fixation system integrates a force gauge for measurement of the vertical force of the head-pins. Less than 80 pounds (about 350 N) of vertical force is recommended for adequate head fixation.[3]

The Sugita multipurpose head frame system (Sugita frame; Mizuho Ikakogyo Co., Ltd., Tokyo), developed in 1978, is another head fixation system that has been widely used for over 30 years.[4–8] The Sugita frame has many advantages for microscopic procedures, but there is no integrated force gauge for the head-pins. Recently, the Dispo-pin® (Mizuho Ikakogyo Co., Ltd.) has been available as a disposable head-pin for use in the Sugita frame. In contrast to conventional head-pins, the tip of the Dispo-pin is separable from the body. Therefore, understanding the difference is very important. Although appearances are similar, the torque for adequate fixation is quite different.

This study illustrates the differences between the two types of head-pin. The mechanism of head-pin screwing, and the relationship between torque and force of the head-pin are discussed.

Features of the Sugita Multipurpose Head Frame and Head-pin

The main features of the Sugita multipurpose head frame system have been described in previous studies.[4–8] Briefly, the Sugita frame consists of two parts: head frame and head holder. A semicircular basal frame, which holds self-retaining retractors st-

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ably near the operative field, supports microscopic procedures. By rotating the head holder, the approach angle can be changed without adjusting the focus and placement of the operating microscope. The patient's head is set in the center of the head holder and is fixed by four head-pins (Fig. 1). The two types of head-pin, Dispo-pin and conventional pin, have similar designs. The body of the head-pin has a thread with pitch of 1.5 mm per turn. The tip of the head-pin is conical in shape with one notch. However, the tip of the Dispo-pin is separable from the body (Fig. 2). There is very low friction (10 Ncm/400 N) between the tip and body of the Dispo-pin. In head fixation, the torque, which is necessary to turn the head-pin further, gradually increases with head-pin screwing. The head fixation procedure depends on the surgeon's experience. The extent of head-pin screwing is judged from rotation number and torque increase of the head-pin. However, the torque increase is different for each individual patient and each type of head-pin. To understand the mechanism of the torque increase, a basic examination was performed.

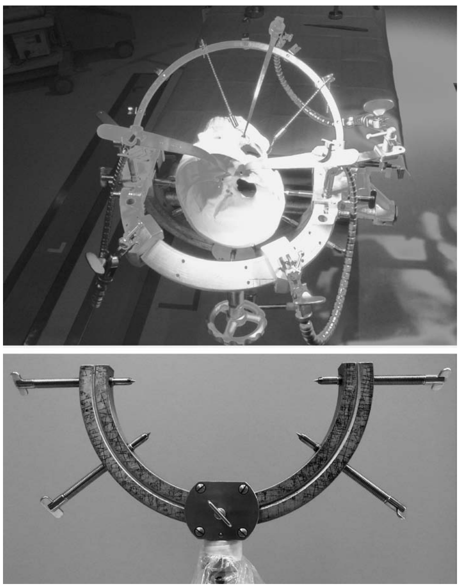

Fig. 1 Photographs of the Sugita multipurpose head frame system showing the whole system with skull model, basal frame, subframe, self-retaining retractor, and brain spatula set on the head holder (*upper*), and the head holder with 4 head-pins (*lower*). The patient's head is set at the center of the head holder and is fixed using the head-pins.

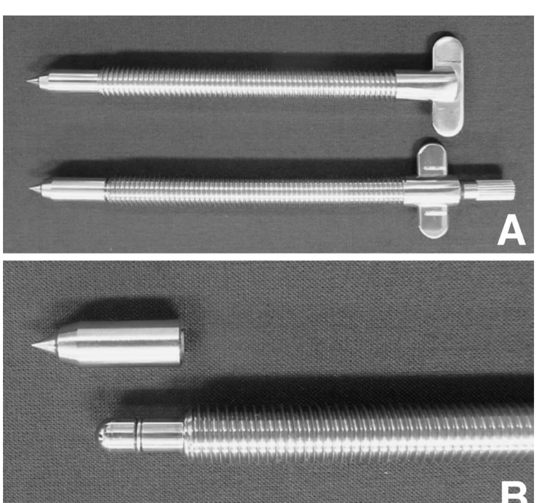

Fig. 2 Photographs of the head-pin of the Sugita frame showing the conventional head-pin (A, *upper*) and Dispo-pin (A, *lower*), and the tip of the Dispo-pin which is separable from the body (B). There is low friction between the tip and body of Dispo-pin.

Materials and Method

We investigated the relationship between the torque and the vertical force applied to the head-pin in the Sugita frame. The Sugita head holder, conventional pins and Dispo-pins, which are clinically and routinely used in our hospital, were prepared. A force gauge (FGP-100; Nidec-Shimpo Corporation, Kyoto) was set at the center of the head holder instead of the patient's head. Three types of materials (stainless steel board, pig femur bone, and hard rubber) were placed between the head-pin and the force gauge. The vertical force of the head-pin was measured by

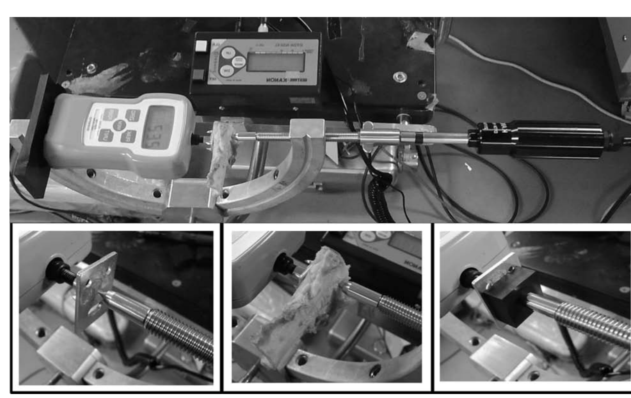

Fig. 3 Photographs of the basic examinations. *Upper*: Force gauge is set at the center of the Sugita head holder, each material is placed between the head-pin and force gauge, and the vertical force of head-pin is measured by changing the torque. *Lower row*: Examined materials: stainless steel board (*left*), pig femur bone (*center*), and hard rubber (*right*).

adjusting the torque from 10 to 140 Ncm until the vertical force is beyond 400 N. The torque was measured with a torque gauge (DTDK-N5EXL; Nakamura Mfg. Co., Ltd., Tokyo) (Fig. 3). Measurements were repeated four times for each type of material and head-pin. All data for the conventional pin were obtained using the same head-pin and the same head holder. All data for the Dispo-pin used the same pin body and the same head holder, but the tip of the Dispo-pin was changed for every measurement. Statistical significant differences were assessed using Student's t-test for unpaired samples. Difference between means were considered significant at $p < 0.05$.

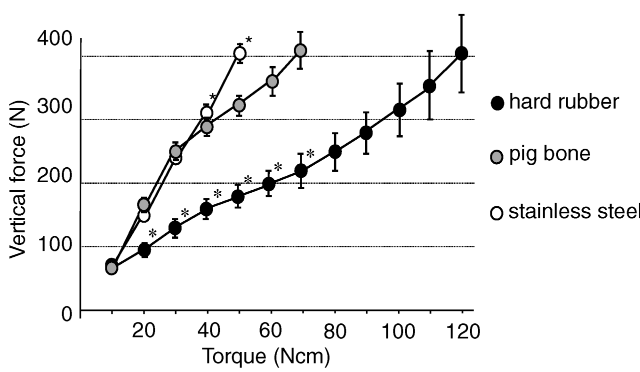

Fig. 4 Graph representing the relationship between torque and vertical force of the conventional head-pin. The point and vertical bars represent the mean and standard deviation of the measured value (n = 4). Torque increase against a specific increase of vertical force was low with stainless steel board and high with hard rubber. *Statistical significance ($p < 0.05$, Student's t-test for unpaired samples) versus the pig bone.

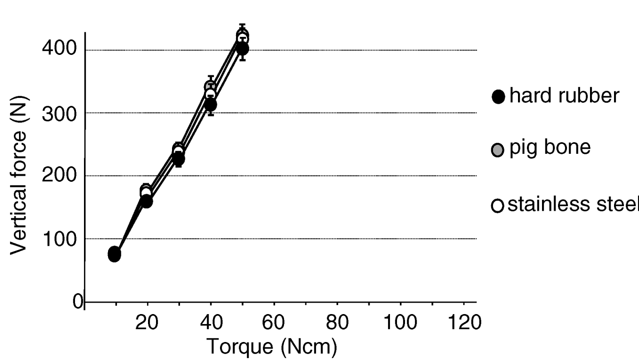

Fig. 5 Graph representing the relationship between torque and vertical force of the Dispo-pin. The point and vertical bars represent the mean and standard deviation of the measured value (n = 4). Torque increase against a specific increase of vertical force was the same regardless of the materials.

Results

The torque on the head-pin was linearly correlated with the vertical force for each type of head-pin and each material. The relationship between the torque and the vertical force on the head-pin was different for the Dispo-pin and conventional pin. Each material caused different torque increase with a specific increase of vertical force using the conventional pin. Torque increase against a specific increase of vertical force with the stainless steel board was low and that of the hard rubber was high (Fig. 4). On the other hand, torque increase against a specific increase of vertical force was same for the Dispo-pin with all materials (Fig. 5).

Discussion

The head-pin of the Sugita head fixation system has a pitch of 1.5 mm per turn, so one turn of the head-pin causes the tip of head-pin to travel 1.5 mm vertically. Insertion of the head-pin causes deformity of the skull. The restoration force of the skull pushes back on the head-pin in the same vertical direction. This force causes the torque on the head-pin (Fig. 6). However, the torque caused by the same vertical force was smaller for the Dispo-pin than for the conventional pin.

Torque on the head-pin is generated from two factors. One factor is the thread between the head-pin

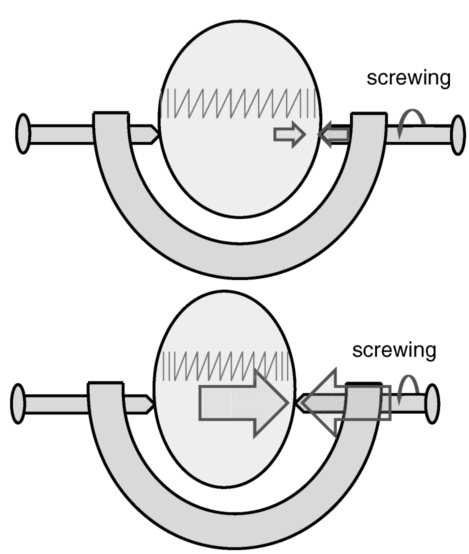

Fig. 6 Diagrams indicating the mechanism of the head-pin in the Sugita head holder, before (*upper*) and after (*lower*) head-pin fixation of a patient's head. The insertion of head-pin creates deformity of the skull. The restoration force from the deformity of the skull pushes back on the head-pin vertically.

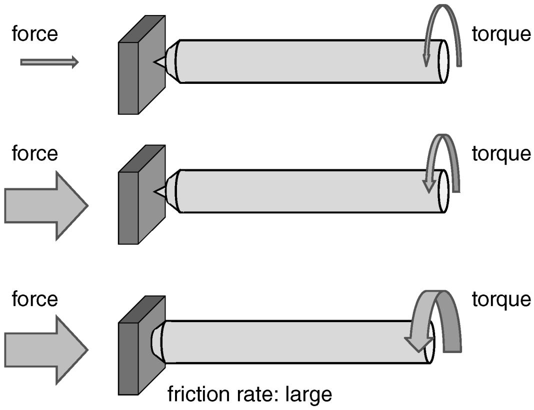

Fig. 7 Diagrams indicating the mechanism of torque for the conventional head-pin. *Upper*: Small vertical force creates small torque. *Middle*: Torque is proportional to the vertical force when the friction force is the same. *Lower*: Torque is higher with the same vertical force, if the friction rate is larger.

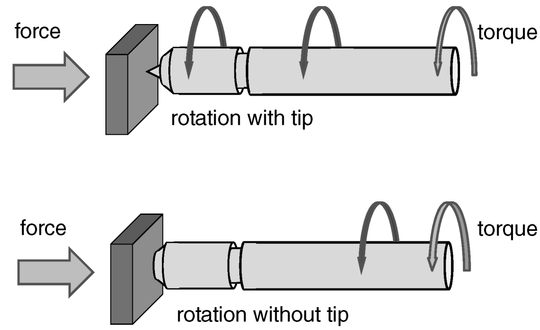

Fig. 8 Diagrams indicating the mechanism of torque on the Dispo-pin under the same vertical force. *Upper*: Under low friction force between the scalp and tip of the Dispo-pin, the head-pin rotates with the tip. *Lower*: Under high friction force, the head-pin rotates but not the tip. The torque, which originates from the friction between the tip and body of the Dispo-pin, is the same regardless of the friction force between the scalp and tip of the head-pin.

and head holder, where the torque from the thread of head-pin is positively correlated to the vertical force according to the law of screw thread force. The torque of this part against the vertical force is same regardless of the head-pin. Another factor is the force acting on the tip of the head-pin. The torque originates from friction between the scalp and the tip of the conventional head-pin. As the friction is different for each patient, the torque at this part is different (Fig. 7). In contrast, friction between the tip and body of the Dispo-pin is very low. As the friction between the scalp and the tip of the Dispo-pin is bigger than that between the tip and body of the Dispo-pin, rotation between the tip and body of Dispo-pin occurs. In consequence, the torque generated from the tip of the Dispo-pin is the same in each situation (Fig. 8). Consequently, the torque on the Dispo-pin generated by the vertical force was the same for each situation. If head fixation with 350 N of vertical force (recommended maximum force in the Mayfield system) is needed, screwing can be done with torque of about 40 Ncm using the Dispo-pin. We recommend that surgeons using the Sugita head frame system should evaluate screwing torque using a torque gauge.

Torque on the head-pin gradually increases with screwing even with different skull consistency and thickness in each patient. Once fracture occurs during head-pin screwing, the pushing back force decreases or disappears. If decrease in torque is felt with additional head-pin screwing, the procedure should be stopped to avoid brain injury. Different skull consistency gives different pushing back force even with the same skull deformity. Restoration force caused by a specific skull deformity is smaller for soft bone than for hard bone. The torque against skull deformity is also small. When the torque increase is slow, excess screwing of the head-pin to reach the usual torque is dangerous, because skull penetration may occur in soft bone before reaching the usual torque. On the other hand, torque increase with head-pin screwing means safe fixation. Strong and safe fixation of the head-pin can be achieved when the torque increases. Fracture of thin bone is encountered before the torque increases. The squamous and suboccipital parts of the bone, frontal sinus, and air cell of the pyramidal bone are thin bones. Care must be taken for head-pin screwing at thin parts of the skull. If tight head fixation is required in pediatric patients, the head can be fixed with the maximum 6 head-pins in the Sugita frame; with this method, pressure on the skull by each head-pin can be minimized.[7)]

The physiological aspects of the mechanism of head-pin screwing were discussed. Torque on the head-pin depends on the restoration force from the skull deformity compressed by the head-pin. Surgeons should recognize the turns of head-pin screwing and torque increase. The torque of the head-pin should be adjusted according to patient's age, condition, and position. Stronger fixation is possible if the head-pin torque increases. The Dispo-pin and conventional head-pin have important differences in characteristics.

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Conflicts of Interest Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices in the article. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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