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A new dynamic arm holding device for microsurgical operations in neurosurgery

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ABSTRACT

The hand holding devices are generally used during the course of micro-surgical operations in neurosurgery to prevent hand tremor. Recently we designed a new instrument for holding two arms. This instrument used for stabilization of two arms especially during microsurgical operations. We used this instrument in different type of operations such as aneurysm surgery, brain tumor surgery, hypophysis surgery, pontocerebellar tumor surgery and posterior fossa surgery. The ability of the instrument in the preventing of arm tremor, and comfort of the arm during surgery was graded as bad, good and excellent in terms of the description of surgeon during microsurgical operations. This instrument was used during 20 neurosurgical operations. The capability of the instrument during microsurgical operation was found as excellent in 65% of the operations. The capability was found as good in 35% of the operation. In conclusion; this instrument holds two arms in the same time and provide unrelated moving from each others. The capability of this instrument is high in the preventing of hand tremor. This instrument may be used during microsurgical operations in neurosurgery.
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1. Introduction

In the development of new surgical instruments and their practical using, brain surgery has a very special place in the history of medicine. Many surgical instruments had been developed for using in neurosurgical operations. The majority of these instruments is used the main part of surgical intervention and the others take actions to support the surgery. Design of these instruments is usually made by the neurosurgeons. An idea was developed for a better and more easily doing a part of the operation. Developed these ideas are translated into a design. Then, the design was turned into a drawing in accordance with a plan, and drawing was given to the masters and prototypes were produced. These produced prototypes are used during surgery and a much more improved during intervention, and after general production is started. This is no way that could not be reached in the brain. Yasargil (Yaşargil, 1977; Yaşargil, 1978; Yaşargil et al, 1988; Yaşargil, 1997; Yaşargil , 1999; Yaşargil, 2005; Yaşargil, 2010), Sugita (Sugita et al., 1978; Sugita et al., 1979; Sugita et al., 1980), and Gilsbach (Gilsbach et al ., 1984; Gilsbach et al., 1994) such peoples are among those leading the design tool. An idea creating a new design is the searching of an answer for this question “how can I do better this operation?” Another question is “how the previously developed device is modified for better performance?” The answer for this question starts a design tool. Every person at every level in brain surgery may be able to design of the instrument. For this purpose, no matter what stage of the profession, a small energy is quite enough to convert small basic idea to a design. They are required to be a good observer, of course. The loss of the design should not be allowed at the stage of idea. In addition, each consisting of ideas should be discussed among peoples. A critical step in the development of tools “I have an idea for this work” phase.

In the other hand, the importance given by the country’s research and development activities is important in the development of new tools in every area. Research areas, supporting of researchers, and supporting and strengthening of the research infrastructure is important. Our device is designed and produced as a result of our effort and our facility. It covers the development of a new armrests system and re-design of systems widely used in microsurgery in the operating room.
First question is; “Is there a need for hand rest systems in brain surgery?” To find the real answer to this question, we should have a brief knowledge about microneurosurgery, the operating microscope, microsurgical instruments and methods used in microsurgery. The term of Microsurgery is used to describe the surgical intervention producing minimal dam-

age to normal tissues around the pathology with maximal surgical treatment to the pathologic area. Microsurgical operations are done under the magnification providing by operating microscope in the neurosurgical operations. The display of the operating microscope provides details of the tissues. In this way tissues are magnified but the hand movement is getting increase under the operating microscopic magnification. The holding of microsurgical instruments such as bipolar forceps, microscissor, microdissectors, and microaspirator are extremely important without hand tremor. Microsurgical techniques include dissection, separation, retraction and resection of the lesion. Basically, these processes can be seen as simple and rude. However, tumor removal process with protecting of fine vascular structures around is a not simple and rude process. For example, an insular tumor resection, the process of tumor removing should be done with protecting of talamoperforating artery. For this purpose, separation of the vessel, retraction of the surrounding neural tissues, dissection and resection of the tumor should be carefully done under the magnification of operating microscope. It is difficult to keep the hands in a fixed position for long periods in a narrow field of a microscopic area without exhausting. In the long-lasting micro-surgical procedures hand rest systems are needed to prevent or delaying of hand fatigue. Therefore, the need for hand rest and systems should not be discussed.

Waiting solution to the second question is what kind of hand rest system is the best and ideal for this purpose. Different type instruments are designed for arm holding during microsurgery. There are various features of each of these devices. It has been designed by different people. It has some advantages and disadvantages during use. No doubt the ideal armrest system is the creation of a system that supports the movement of all kinds of hand. This type of system armrest system is referred to as dynamic. To be a dynamic armrest system is that the mechanisms of self-insertion motion. Movements, according to the coordinate system in space are to have the ability to move up and down the back of the front. In addition, during surgery, a loss of time for the necessity of rearrangement of system is another important feature. When these devices ever developed for this purpose, we see that all of these devices are static devices instead of dynamic devices. It can not adapt to new situations and re-adjustment is necessary during the procedure. From affecting the concentration of re-adjustment process as well as surgery was defined as a time-consuming process. We designed a new instrument for holding arm during microsurgical operations. The device was produced by surgical instrument factory in Samsun. This instrument was used in our microsurgical operations. In this study we investigated the capability of this instrument in the holding capability of arms.

2. Materials and methods

Previously in our operating room T shaped instrument is used during microsurgical operations. This device rests on the ground with a circular table. It includes a long-standing parallel to the ground with a height-adjustable system that allows the alignment of the arm perpendicular to the ground. This system also has armrest system parallel to the ground. This armrest system can be defined as static armrest system. Because of the arm remains in a constant, it doesn't respond to the back and forth movements of the arms. These deficiencies in the system has been developed taking into account the new armrest.

General features of the system

The system is a dynamic system in general. This feature is one of the most important features of other systems for allocation. Forearm may be supported from any point of the arm. In addition, the two arms can move independently. This gives the ability to move separately during surgery. Because of these properties in the nature of this system is a dynamic system.

Parts of the system

Floor plate

The floor plate is composed of a relatively heavy disc on the center of which the main carrier post of the system is vertically erected. The carrier post is a one meter high, rotatable tube in which the carrier peg of system slides up and down. It is equipped with a screw-action grip for height adjustment. On the floor of the operating room, floor plate is placed in the most convenient spot for surgical approach, amenable to be relocated if required (Fig. 1).

Fig. 1. The floor plate of the system

Arm support apparatus

Arm support system is consisted of two armrests mounted on a Y shaped frame. The frame (Fig. 2) is consisted of a vertical base from the top of which 2 curved posts diverge. Depending on the version of the system used, the curved posts can either move independently, or cross-linked by a gear system.

Armrests

Each sterilizable armrest is mounted on a vertical post via either an adjustable uniaxial gear-action hinge, or a sagital gentle moving ball and socket joint. At the bottom of the posts, there are spring action collet type chucks, accommodating the tapers of the curved posts (Fig. 3, 5). The vertical posts can rotate freely by the chucks. The armrests can be fitted with elbow rests for procedures which requires the hands to be on a higher level, or silicone banded wrist supports for conditions requiring increased microsurgical precision (Fig. 4).

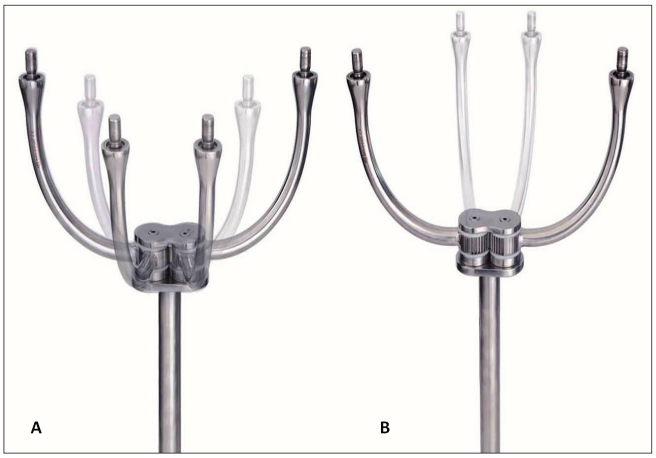

Fig. 2. Arm support systems with independent moving (A) and cross-linked (B) curved posts.

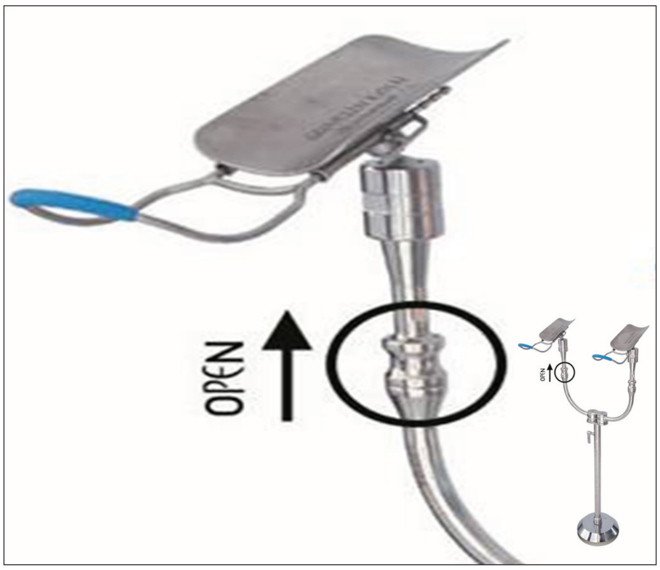

Fig. 3. Collet chucks in action

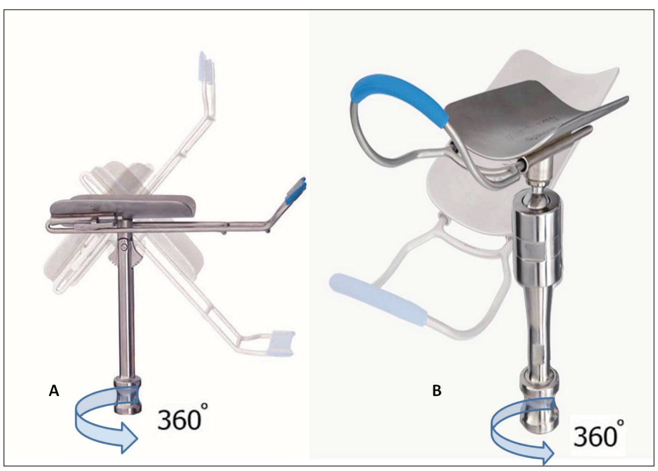

Fig. 4. Armrests fitting on the curved posts. A: armrest design with gear action sagital hinge allowing a 90^0 range of motion with 6^0 intervals. This armrest is fitted with silicone banded wrist support. B: armrest design with sagital gentle moving ball-socket joint. This armrest is fitted with elbow rest.

Fig. 5. System draped for surgery, with only its sterilized parts exposed.

Evaluation

In the evaluation of the instrument, we used an evaluation scale. This scale includes three degree as bad, good and excellent in the description of the surgeon.

3. Results

This instrument was used in 20 microsurgical operations. We used this instrument in different type of operations such as aneurysm surgery, brain tumor surgery, hypophysis surgery, pontocerebellar tumor surgery and posterior fossa surgery. The capability of the instrument during microsurgical operation was found as excellent in 65% of the operations. The capability was found as good in 35% of the operation.

4. Discussion

From lenses to operating microscope

Lenses in the historical perspective have been known for a long time. Magnification and inspection of the details of the objects in this way had been innovated (Kriss et al., 1998). Lenses are used in the correction of refractive errors for many years. However, innovation of a microscope or a telescope by using multiple lenses was done many years later. In 1609, Galileo Galilei developed a compound microscope with a convex and concave lens. In 1674, Anton van Leeuwenhoek improved on a simple microscope for viewing biological specimens with multiple lenses. Using simple lenses, people have developed more complex and more complicated devices and have begun to use these devices for different purposes. Surgical microscopes have been used for many years after the invention of the lens. Surgical microscopes have been used in ear surgery for the first time (Kriss et al., 1998).

Using of operating microscope for neurosurgery

The innovation of operating microscope is a milestone for neurosurgery. Even if it appears to have no effect of brain surgeons on the invention of operating microscope, magnification is most needed during surgical intervention on brain tissue. Neurosurgeons have been the contribution of the intellectual development of the operating microscope. Neurosurgeons about the effect of this is a fact that more than other disciplines. Operating microscope has been widely used in neurosurgical operations after the first invention. Before it was started to use in tumor surgery and later it was started to use more commonly in the aneurysm and other vascular lesions. The most important person to be adapted to neurosurgical operating microscope is Yaşargil. Previously he worked in experimental subjects and then he applied vascular anastomosis techniques under the operating microscope. Then the operating microscope has become an indispensable device in neurosurgical operations. Become a more frequently used in neurosurgical operations it was developed. Better quality and more advanced mechanic and electronic systems are equipped with lenses. The most important one among these systems is contra-verse systems. With this system neurosurgical operating microscope has gained moving ability. And then microscope microscope becomes a more dynamic device. So that with the mouth switch and a small hand movement it has become a moving device.

From macrosurgery to microsurgery

The term of microsurgery was being used after the 1960s. Microsurgery is used to describe repair, dissection, resection, separation, ecartation and suturation techniques by using microenstruments under the operating microscope. Yasargil is the most important person in the development of microsurgery (Yaşargil, 1977; Yaşargil, 1978; Yaşargil, 1988; Yaşargil et al, 1988; Yaşargil, 1997; Yaşargil , 1999; Yaşargil, 2005 Yaşargil, 2010). Microsurgery is the name of the most important source of books written in this field. In these books, the topics was described both written and visual in full detail. As described previously, Yaşargil performed vascular microanastomosis under the operating microscope and microenstruments (Yaşargil, 1977; Yaşargil, 1978; Yaşargil, 1988; Yaşargil, 1988; Yaşargil, 1997; Yaşargil , 1999; Yaşargil, 2005 Yaşargil, 2010., ;). He dissected the vessels, and separated it from surrounding tissues under the magnification. And then microclips were applied to the vessel and cut the vessel before microsuturation. Blood flow has gained again. He performed working anastomoses. He performed working anastomosis in humans. The era of microsurgery was started in this way. The success and types of surgery positively increased.

History of hand-rest systems

Microinstruments for microsurgery were improved gentle in shape during the development period of magnification, operating microscope, and microneurosurgery. The techniques were developed for handling of these instruments. In the developing of such kind of instruments, the role of neurosurgeons was very important but in the other hand the role of medical instruments producing factories such as Aesculape, Codman, Mizuho, Bahadır and Aygün were also important in terms of efforts for new instruments designations and productions. The head holder frame developed by Sugita includes hand holder system and mikroretractors (Sugita et al., 1978; Sugita et al., 1979; Sugita et al., 1980). In the other hand, operating seat developed by same surgeon, and produced by Mizuho factory is used in the present time during microsurgical operating rooms. Gilsbach system, in the same time, includes hand-rest system for microsurgical operations (Gilsbach et al ., 1984; Gilsbach et al., 1994). The hand resting device used by Yaşargil is T shape device seated firmly on the ground. This system is a mobile system and it can be moveable back, front, left and right side. This system can be used free from head holder system.

Dynamic hand resting

There is no doubt that the necessity of hand resting systems during working on the area of microscopically magnified. The majority of the systems developed for this purpose are static systems instead of dynamic systems. In the explanation; this system is set up just before starting the operation and the surgeon checked up the position of the system according to the type of the operation. The hand and forearm resting system developed by us is a dynamic system instead of static system. The term of dynamic is used to describe for following; in the operations the system is re-set up and optimized by a small hand and forearm movements according to necessity. The operator is not spending his/her time during making operation for setting up hand resting system. In the other hand, another advantage of dynamic hand resting system is the moving of the system with small hand movements without interruption of hand holding and supporting. For this purpose, dynamic system with multi joints was developed. Movements are produced by joints of the system. This system is designed in modeled from hand and forearm joints.

Hand rest for sitting position

One difficulty among other difficulties of microneurosurgical operations is the different position of the patients instead of stabile position. May be the most problematic position among these positions is the sitting position. This position generally is used for posterior fossa approaches. Some important approaches in these interventions are surgical intervention for pontocerebellar angle tumors, and surgical interventions performed for vascular pathologies of posterior fossa structures. Sitting position is also preferred for some pathology located in the pineal region and occipital cortex. In this position the head of the patients are positioned just eyes looking in front position. The operating microscope is located from behind and repositioned according to the type of the pathology. In this position the hand and arm resting device should be used for forearm and forearm joints. For operation the hand should come to the patients head at some angles. This is the most hand tried position in neurosurgery. Our new system we have developed has two different advantages. One of them is a dynamic system for supporting the forearm. The second important advantage is soft supporting to the forearm joints via soft silicon bands without extra pressure on the radial and ulnary nerve during operation.

The system adopts itself according to new position when the position of the operating microscope is changed depends on the any changes of the working area. The system may be able to adopt to the new position even the direction of the operating microscope changed many times. Another advantage in addition with these practically detected advantages is the occupation of small space around the operation area. This system is specifically completely free from head holder and retraction system. After completing the craniotomy in the steps of the opening the dura mater (generally the operating microscope is carried to the operating area at this step) the altitude of the system is arranged at this step. All of other movements are produced by articulations in where located within the system. The degree of the articulation balancing in the same time can be optimized preoperatively and real-time intraoperatively as desire of the surgeon. Among the hand resting systems, in the posterior fossa surgery, this system is a unique system in terms of supporting hand, forearm and elbow (Fig. 6).

Hand resting for supine position

Fig. 6. Armrest is positioned so that forearms and elbows can be supported so that they can curve around the operating microscope to approach the posterior fossa.

Generally the head is supine during supratentorial brain surgery. During this type of surgical intervention hands are transverse plane and the apparatus provide arm support in transverse plane on the ground. In the other hand, during the posterior fossa surgery hands are oblique to the head. This instrument can provide the supporting of different angle to the forearms. The silicon bands also hold the hands and provide resting during surgery.

In supine position, the operating microscope is generally located over the patients head. Usually the surgeon's hand come from superior direction and relatively parallel to the operating site. In this position, it is necessary to support of hands and forearms. Sugita and Gilsbach's hand resting systems is circle in shape and more close to patient's head. These systems are static systems. In our system, hand resting apparatus may be positioned parallel to the head with a mobile system. It can be mobile with its joints and can be moved superior, inferior, right and left directions. It is unnecessary to montage with head holder system. This prevents the unnecessary loss of time.

Hand resting for vascular neurosurgery

The history of vascular microsurgery started with the operating microscope (Yaşargil, 2010). The quality of operations has increased after the introduction of operating microscope. Operative field is narrowed and operation time extended in relation with vascular pathology. Magnification of normal and pathological vascular structures provides a different point of view to surgeon during the surgery. Dissection, separation and retraction of neural tissues need delicate and gentle movement of hands and fingers in the maximal protection of tissues. During the operation the surgeon's hand movements should be regular and balanced. There is an importance of hand resting to ensuring the comfort. For this reason hand resting is necessary for successful vascular surgery. For this purpose some instruments had been developed to help surgeon.

Aneurysm surgery is one of the problematic areas in neurosurgery. The most important step of the surgery is the dissection of arachnoids mater, separation of vascular structure and dissection of perivascular area. Prevention of hand tiredness and keeping of the hands a constant position during aneurysm surgery is extremely important. Especially in aneurysm surgery high level magnification is used. For this reason constantly keeping of hands is important for safe surgery. Especially in problematic cases, long lasting surgery is necessary for clipping of the aneurysms.

Hand resting for brain tumor surgery

Brain tumors originate from supratentorial and infratentorial neuronal structures. Patient position can be changed depends on the location of the pathology. The position of the microscope may be changed depends on the location of the lesion. Tumors may locate superficial or deep inside the brain. Dissection, separation, retraction and resection techniques are used for tumor surgery. The surgical instruments include bipolar forceps, aspirators, microdissector and cavitron ultrasonic aspirators during surgery. The basic principle of surgery is to make maximal tumor resection with minimal surgical damage of normal brain tissue. In the maximal protection of neural tissues, hand and elbow resting system is very important. In neurooncologic surgery, hand and arm rest system of self articulated is providing constant hand resting. Using of this system may enhance the success of the surgery. Especially in the long lasting neurooncologic surgery, resting of the hands during surgery seems an effective method for hand resting.

Hand-resting for cranial base surgery

Quite different positions are used in neurosurgical operations for skull base surgery. Such kind of operations takes long time and during operation surgeon uses micro-drill for removing of the cranial base bone. Micro-dill should be kept constant during the removal of bone and it is pressed with a constant and gentle pressure. Using of the micro Drill with a certain angle to keep as a constant and in addition to this particular application, using of a gentle force is extremely important. Especially in the drilling of the bone structure around the cranial nerves and vascular structures, the hand holding of the wrist in a fixed angle, and in this way be important to continue to surgery. In the system we have developed, primarily forearm fixed and kept in the desired angle, and surgical maneuver are covered by the system.

In addition, the system is completely independent from the right and the left arm. Thus, the surgical instruments can be hold with the right and the left arm and can work independently.

Conclusion

The development of microsurgery has become mandatory to provide hand stabilization. A hand resting apparatus is necessary during microsurgical operations. We designed a new type hand resting apparatus during microsurgical operations for hand stabilization. This device is a self-jointed and a dynamic stabilization system.

This instrument is designed for maximal providing of hand comfort during surgery. The apparatus for hand holding are metals. The shape of this metallic apparatus is designed to holding of forearms as curve. This device is used in many microsurgical operations. According to our experience, this apparatus provide an excellent supporting for hands and forearms during surgery. This instrument may be used during microsurgical operations in neurosurgery. This system is a system that provides a dynamic stabilization of the hand. Use of this system will enhance the success of surgery.

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