CLOSED FRACTURE REDUCTION USING MOTORIZED REMOTE CONTROLLED REDUCTION DEVICE

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ABSTRACT
The objective of this study was to test clinically one new portable, motorised, remote controlled fracture reduction device. In vivo fluoroscopic analysis of the function of the device. Radiation exposure of the surgical team during fluoroscopy is one potential danger for the health. Minimal invasive surgery searching for reduction device which will hold position of the fragments during the fixation. Visual analysis was performed in 20 bone models (n=20) and fluoroscopic in vivo (n=6) closed fracture reduction using motorised, remote controlled reduction device. In vivo results showed average closed tibial and femoral fracture reduction for 96 sec. Reduction was successful in all patients. Position of the fragments was held until definitive fixation. Motorised remote controlled device is helpful in obtaining relatively quick fracture reduction with reducing of irradiation exposure of the surgical team and in holding of achieved reduction. Remote controlled, motorised reduction device reduces irradiation exposure of the surgical team, but also minimally invasive fixation methods could take advantage of easy reduction and holding of the fragment position until fixation. Motorised reduction device could be useful tool implemented in computer added reduction and robot.

Introduction
Minimal invasive surgery is desirable because it decreases intraoperative trauma, possibilities of complications, the duration of treatment and overall cost. Reduction device would contribute to minimally invasive surgery providing quicker fracture reduction with closed method. Radiation exposure of the surgical team during fluoroscopy is one potential danger for the health of the team. Working near to fluoroscopic beam this staff receive significant amount of radiation (1). Using of one remote controlled reduction device can exclude potential consequences of intraoperative radiation.

Several authors tried to develop reduction devices (1-4, 6-10) but no one published motorised nor remote controlled one. Developing and introducing such ideas in orthopaedic trauma practice will bring progress not only because of protection of the surgical team from radiation, but also, because of possibility such system to provide quicker fragment reduction using different methods of assessment of fracture reduction.

The goal of this work is to test clinically one new small size, portable reduction device which is applicable to different long bones.

Materials and Methods
Device
It has been used the originally made device which consists of 5 motorised units: four
with arches and one with bar (Fig. 1). Each unit with arch, consists of arch, motor and sleeve-guidance for the arch. Moment force from the motor to arch or to telescopic bar is transmitted via gear. Connections between the motors and the arches or telescopic bar are self locking providing movement in forward and backward direction. The device is supplied by 12V battery which is connected to each motor. For each of two main bone fragments it is employed one pair of units with arches, so that one arch is in sagittal and another in frontal plane. Fifth unit which consists of the telescopic rotatory stable bar, sleeve and motor, connects two pair of units with arches and provides distraction or compression. The device has two bars connected on each (proximal and distal) end. The reduction device is connected to the pins introduced in each of main two bone fragments, using the clamps of the Mitkovic external fixator as the diameter of these two bars is the same as diameter of the bar of external fixator. Pins were introduced convergently without any guidance because clamps of Mitkovic external fixator provides high mobility of the System. Before locking of the clamps which connect the reduction device to the pins, operator hold the leg in neutral rotation and assistant performs the locking. It is desirable centre rotation of each arch to be in the long axis of the bone. Reduction device so, doesn’t interfere with bone, during the fluoroscopy time (Fig. 2).

For the reduction of the fracture with two main fragments, it is necessary to correct four kind of dislocations: translation (ad latus), angulation (ad axim), rotation and length. Reduction of ad latus and ad axim dislocation is performed by rotation, using arches, while distraction and compression is performed using telescopic unit. Rotation is set manually before starting of reduction and it is corrected manually, if necessary. We didn’t include separate arch for rotation correction, because rotation can successfully be set manually before starting of reduction device.

Controlling of the work of the motors is performed by remote control. Control stick is supplied by forward and backward button for each motor and it is designed like joystick so to be easy to use both hands and to control more then one motor simultaneously.

Hole device was sterilised using gas sterilisation.

Reduction is performed by surgeon from the distance bigger then 2 meters. C-arm of the image intensifier is first in AP position and after achieving reduction it is altered.
for lateral position.
After fracture reduction is completed, already applied external fixator is locked on the same pins. Reduction device is removed then.

**Patients**
Six patients have been involved in this study (5 with tibial and 1 with femoral fractures). Fractures were 1.5 days old average (0-4 days). The average age was 42.6 yrs (19-67). Eleven were male and six female. Spinal (subarachnoidal) anaesthesia has been performed in 5 and general in 1 patients. For this study we selected closed diaphyseal (5) and metaphyseal (1) fractures which will be treated by the use of high mobile Mitkovic external fixator. Using AO classification, 3 A2 fracture, 1 A3 fracture, 1 B1 and 1 B2 fracture.

**Results and Discussion**
The time of application of 2 pins in each of two main fragments and setting of the reduction device to the pins was 15 minutes (9.5 - 19.5). Average reduction time was 96 sec (35 - 287). This time represents the fluoroscopy time. Surgical team was on the distance more then 2m from the image intensifier. The surgeon followed operation on the monitors of image intensifier performing remote controlled reduction procedure. Reduction time using motorised remote controlled reduction device, in the first three patients was longer in comparison to the reduction time of later patients. In all 6 patients it has been successfully achieved fracture reduction (Fig. 3).

It was relatively simple for understanding and handling of this system.
Manual correction of the rotation has been performed only during the reduction of one tibial fracture.
Minimally invasive surgery is more and more desirable (11). It decreases the duration of overall fracture treatment, the complications as osteitis and the overall cost. In orthopaedic trauma surgery one of the main problem is satisfactory closed fracture reduction after which, fixation can be simple on minimal invasive manner. Closed fracture reduction using reduction devices makes easier minimally invasive surgery. Several authors tried to develop different reduction tools or reduction devices (2 - 4, 6 - 10). Some of them are designed only for lower or upper extremities and other for
one specific segment. We have developed one smaller size reduction device, portable and relatively simple for handling. Using *in vitro* and *in vivo* of this device, we received satisfactory results. Average time of pining, setting of the reduction device and achieving of satisfactory reduction was 16.5 minutes. But average fracture reduction only, was 96 sec which represent the fluoroscopy time. The system has been successfully applied to femur and tibia. Our reduction device is remote controlled. Stereointerfluoroscopy give more conveniences in orthopaedic surgery (12). Using this technique all together with reduction device, will even more simplify closed fracture reduction. Radiation exposure to the orthopaedic surgical team during fluoroscopy is wide discussed and reducing of this exposure is important (1). Using remote controlled motorised reduction device it is possible irradiation time to be decreased. During the fluoroscopy time, operating team is far from the operating table and fracture reduction is decreased to about 1.5 min. Using of this device can also be helpful in the intentions of computer added fracture reduction (5, 6). This device helps during the reduction but also holds the achieved fragment position until definitive fixation. Remote controlled, motorised reduction device is very suitable to be hardware component in using robot for fracture reduction. Classical fracture table can be avoided using of this reduction device (10). All of our patients have been treated without using of fracture table. This reduction device has been successfully used for the treatment of diaphyseal and metaphyseal fractures, but what to do with the fractures involving the end parts of long bones and joints? Is it sufficient to introduce pins in neighbouring segment like introducing the pins in proximal tibia, for distal femoral fracture reduction? Also, method of the connections between the bone and reduction device in the case of intramedulary nailing, has to be improved.

Reduction of independent fragment is a separate problem. For these purposes, we have bee developing an accessory reduction device. This device make possible 3
dimensional translation and rotation of the fragment.

According to the obtained results, using motorised remote controlled reduction device, it can be concluded that this tool is helpful in obtaining relatively quick fracture reduction with reducing of irradiation exposure of the surgical team.

REFERENCES