

## **Summary**

Hackethal's bundle nailing of diaphyseal humeral fractures was historically reliable and cheap method, used for stabilization of simple humeral shaft fractures. After arrival of solid nails, this technique was successively abandoned, initially in Germany, followed by countries of Central Europe. Several clinics are at present still using this technique successfully.

Goal of this work was to establish, whether the declared stability of this technique is comparable to those of more evolved methods, whether this technique does not cause higher amount of complications, and to describe how the stability of nails bundle depends on number and diameter of used implants. The cost efficiency of different modern osteosynthetic methods used for stabilization of humeral shaft fractures was also analyzed.

For verification of determined hypotheses, two clinical and one experimental studies were developed.

First clinical study was focused on success rate of osteosynthesis and its complications. In studied population of 50 patients, 4 of them (8%) developed a non-union, which was in all cases caused by wrong indication or technical error during implantation. Superficial infection was observed once, no deep infection had developed. Nine patients (18%) have healed in rotational or axial malalignment that had no influence on clinical function of extremity. Permanent limitation in range of motion of elbow was not observed, gentle limitation in shoulder was observed in 5 patients (10%) other five patients had severe limitation in shoulder. These were older patients with fracture of proximal humeral diaphysis.

Second clinical study analyzed causes of development of non-unions in described osteosynthetic method. In 156 patients involved in study, non-union developed in six of them (3.8%). Mean age of these patients was 62 years (entire study population had mean age of 51.2 years). Older patients were more likely to develop a non-union. Other factor was severity of fracture, more complex fractures were likelier to turn into non-unions. On the other hand the other observed factors, namely soft tissues condition in fracture area, location of fracture line and mechanism of injury did not substantially elevate the probability of a non-union development. Factor with highest influence on fracture healing was incorrect indication or surgical technique (in five cases out of six non-unions).

Goal of the experimental study was to establish in a specified setting, whether the diameter of used implants affects final stiffness of system and the distribution of stress. A parametrical 3D numerical model was developed for testing of bending and torsional stiffness of system using different implant diameter. Testing of the model did prove that bending stiffness is independent on implant diameter, whether the rotational stiffness is rising with higher implant diameter. The same correlation with higher implant diameter was seen in maximum stress in implant during its bending and rotation,

thus causing the implant to fail. Optimal compromise between sufficient stiffness and acceptable stress in implant was observed in nail diameters of 2-3 millimeters.

When comparing the study results with recent works of other authors, it could be stated that elastic bundle nailing technique does not possess higher complication rate compared to solid nails or plates and does not lead to higher rate of osteosynthesis insufficiency. In correct indication, this method is sufficiently stable to achieve fracture healing. Final results of numeric model testing are also comparable to recently published studies. Computed testing is highly dependent on model type and initial setting of conditions.

Considering the study results, Hackethal's bundle nailing technique is sufficiently stable for treatment of simple humeral shaft fractures without burden of higher complication rate, compared to other osteosynthetic methods. Major condition for its successful usage is correct indication (simple fractures without comminution) and correct surgical technique (complete filling of medullar cavity with implants of optimal diameter between 2-3 millimeters). Added value when compared to other osteosynthetic methods are its low financial demands, disadvantage could be narrow indication spectrum with resulting low technical experience of surgeons.