

THE ROLE OF TISSUE OXYMETRY AND DIGITAL DYNAMOMETRY IN THE PREVENTION OF INTERSPINOUS FIXATORS INSTABILITY

Chertkov Kuzma Alexandrovich^{1*}, Chertkov Alexander Kuzmich², Kutepov Sergey³

¹*Sverdlovsk Regional Hospital for War Veterans; External Doctorate Student in Ural State Medical University. Ekaterinburg.*

²*Ural State Medical University, Head of the Chair of Traumatology and Orthopedics, Professor; Ekaterinburg.*

³*Rector of the Ural State Medical University.*

Abstract: The work describes the results of intraoperative tissue optical oxymetry when implanting interspinous fixators in 17 patients with instability in the lumbar spinal segments with the use of a dynamometric digital device. The aim of the study was to develop preventive measures against vascularization disorders in the bone structures as a basic condition for successful osseointegration. The parameters of safe compression (25-27 N/m) of interspinous processes with fixation devices when implanting stabilizing fixators were determined in the course of the study.

Keywords: Instability, Tissue optical oxymetry, Implants, Digital dynamometry, Spinal motor segment

INTERODUCTION

Modern surgical vertebrology is impossible without the use of dynamic and rigid fixation devices, which allow restoring the lost stability of the vertebral segments due to injury or progression of degenerative-dystrophic processes in its various elements. Implantable fixators allow making prosthetic appliance to restore various lost functions of the segments. At the same time, there are frequent problems due to biocompatibility, osseointegration and dissonance of the elastic moduli of implants with bone and cartilaginous tissues.

Therefore, one of the urgent problems in implantology is to develop a technology that can exclude excessive compression and maintain vascularization of bone and cartilaginous tissues in the contact zones of implantable fixators. Currently, during surgical procedures, clinicians do not determine permissible fixator loads on bone tissue. Thus, prosthetic structures often become unstable and have to be subsequently reassembled.

In clinical practice, the development of fixator instability with recurrent pain syndrome is observed in 4.6-85.0% [1] cases of implanting dynamic or rigid fixation structures in the interspinous, interbody spaces.

It is reasonable to assume that when fixators are implanted in interspinous spaces, compression of all the feeding branches of the spinous process by the implantable structure components can lead to ischemia, hypoxia with a change in mineral metabolism, reduction in the elastic modulus, structural and functional properties of bone tissue with the development of instability of fixing elements.

Thus, to reduce the extent of intra-operative tissue damage, it is necessary to monitor saturation in the bone structures contacting with the fixators or retractors, to protect bone tissue and improve its resistance to damaging factors.

The research objective is development of a technology to implant interspinous fixators without violating vascularization in the bone tissue under local and systemic saturation control.

MATERIAL AND METHODS

Our oxymetry studies of spinous processes tissues in the implant contact zones were performed in 17 patients (mean age 37 ± 2.7), during operative stabilization of the lumbar segments with interspinous fixators of dynamic and rigid types (RF patent for utility model No. 128481, design patent No. 87386). All patients underwent surgery on progressive degenerative and dystrophic process in the lumbar segments of the spinal column with the development of disc-radicular conflicts and instability. The immediate indications for surgery were radicular and vertebral pain syndromes resistant to medication and physical therapy.

“LAKK-M” complex was used to assess local oxygen saturation of the spinous processes [2]. The complex provided simultaneous measurement of tissue perfusion with blood, oxygen saturation of hemoglobin (SO_2) and the volume of hemoglobin fraction (V_r) in the probed area, comparing local saturation with changes in cerebral saturation measured by FOR-SIHT (M2000, USA) tissue oxymeter [3, 4, 5]. Compression loads upon fixation of prosthetic dynamic devices were controlled by a torque-measuring wrench with digital display of torque that appeared during fixation of the interspinous fixator (Figure 1).

SO_2 and V_r were assessed by absorption spectroscopy methodology based on different optical properties of oxygenated and deoxygenated hemoglobin fractions. The depth of optical probing was at least 1.0 mm, which reflected the level of oxygen saturation of dense and spongy tissue parts of the spinous processes. Recording was performed by mounting the optical fiber sensor on the side surfaces of the spinous processes and its top; oxygen saturation was estimated in 3-5 areas. Recording fragments with duration of 300 seconds were used for analysis. Before analyzing the LDF-grams, they were aligned parallel to the isoline to

eliminate errors in the analysis of the oscillatory process.

Since the SO_2 parameter is an integral indicator associated with the total volume of biological tissue (the arithmetic mean for the arterial and venous blood) and since microvasculature contains several times less arterial blood rich in O_2 than the vein blood, it was possible to estimate tissue oxygen consumption.

A significant decrease of SO_2 ($p \leq 0.05$) in the bone tissue during implanting interspinous fixator confirmed the hypothesis that excessive compression of the spinous process by the implant was accompanied by changes in gas exchange and decreased tissue oxygen consumption. It caused the development of ischemia of the bone tissue with subsequent changes in mineral metabolism in it and osseointegration processes.

RESULTS AND ITS DISCUSSION

One of the main tasks to be resolved in this study was to determine (using a digital torque device) the parameters of compression load on the side surfaces of the processes and their tops, at which oxymetry parameters corresponded to the basic (prior to implantation) ones and did not lead to a critical decrease of oxygen content in the measured areas of fixator contacts and the spinous process at a controlled force.

According to G.A. Ilizarov, A.M. Markhashov [6], blood supply to the spinous processes is performed by the branches of the segmental arteries of the 2-3 orders, which run on the side surfaces of the spinous processes and divide into 8-10 branches (rarely to 4-6) with diameters from 0.5 to 2.0 mm. Anastomoses in the areas of the tops of the spinous processes are present, but very rarely. Oxymetry values were $78.1 \pm 3.7\%$ when measuring oxygen saturation of the spinous processes structures before fixator implantation.

The gradation step of fixation elements compression on the side surfaces of the processes was 5 N/m. The dynamics of changes in the oxygen saturation of the bone tissues is shown in Diagram 1. We have conventionally considered values less than

60% (at systemic oxygenation values of $88.1 \pm 3.7\%$) to be a critical decrease in oxygen content in the measured areas of the periosteum of the interspinous processes. At excess compressive load (more than 30 N) of the implant fixation elements on the bone tissue of the interspinous processes, oxymetry performance steadily declined, indicating a need to limit compression on the bone tissue to 25-27 N. When oxymetry performance was 65-70% in the tissue processes for 13 – 15 minutes, we observed stable values of oxygen content, which marked the final fixation of the interspinous fixator at a maximum torque of 25 to 27 N/m.



Figure 1: Scheme of recording of saturation in the spinous process at implantation of the dynamic fixator.

- 1 - LDF (Laser Doppler Flowmeter)
- 2 - Light guide
- 3 - Interspinous fixator
- 4 - Torque wrench

REFERENCES

- 1 Kim DH, Tantorski M, Shaw J (2011) Occult spinous process fractures associated with interspinous process spacers. *Spine*. 2011; 36; E 1080-E1085.
- 2 Krupatkin AI, Sidorov VV L (2005) *Laser Doppler flowmetry: A Guide for Doctors*. M.: Medicine, 2005
- 3 Akselrod BA, Tolstova IA, Guskov DA (2013) Monitoring of tissue oxygenation during cardiac surgeries. *Anesthesiology and intensive care*, 2;19-22.
- 4 Akselrod BA (2014) Regional oxygenation in provision of cardiac surgery safety. *Pathology of the blood circulation and cardiac surgery*, 3;25-29.
- 5 Pika TO, Safonova LP (2012) Design parameters of tissue oxymetry in critical care medicine. M.; Biomedical radioelectronics, 2;053-062.
- 6 Ilizarov GA, Markhashov AM (1997) *Blood supply to the spine and the effect of the changes in trophism and load on its shape*, South Ural Book Publisher.

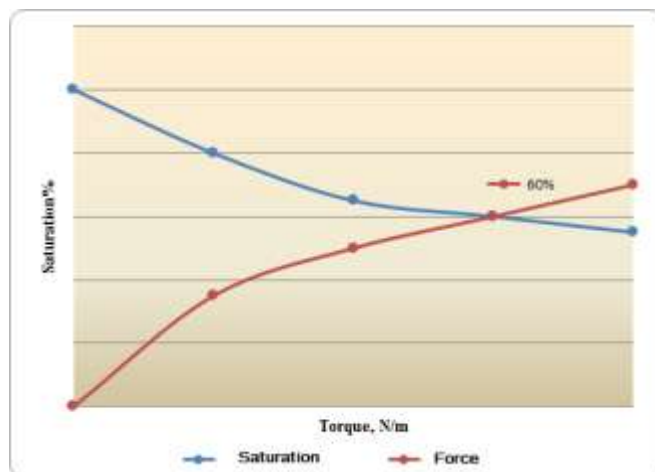


Figure 2: Dynamics of saturation of the tissue of the process depending on the wrench torque

SUMMARY

Taking into account a small number of clinical material and a short period of monitoring the patients with implantable fixators under oxymetry control, we can say (with professional caution) that stabilizing rigid and dynamic interspinous fixators must be implanted under intraoperative control of oxymetry performance in the areas of implant contact with bone elements, under compression of the interspinous processes with a torque wrench on the bone tissues. It is undoubtedly a modern basic element of preventing the development of fixing structures instability.