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ANATOMICALLY ADAPTABLE DYNAMIC TRANSPEDICULAR SYSTEM FOR FUNCTIONAL RESTORATION OF SPINE

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Abstract: *Problem of functional restoration consequences of injuries and diseases of the spine is one of the major socially significant problems of orthopaedics, trauma and vertebrology. Particularly acute problem in the choice of a diseases treatment in children and adolescents. For example as of today there is virtually no implantable systems with the duration of human life. Developed in the laboratory of biomechanics of Sevastopol National Technical University of a new dynamic transpedicular system allows to solve this problem.*
Key words*: spine, scoliosis, technology, implant*

1. INTRODUCTION

Statistically significant is the fact that the diseases and spinal injuries are a major cause of disability rights. For a number of factors the number of patients requiring a specialized vertebral and orthopedic care, is growing. For example, in Ukraine are diagnosed each year more than 60000 cases of adolescent scoliosis and need of surgical intervention (Prodan et al., 2007). However, the lack of methods of surgery and implants that meet the specific clinical situation limits the possibilities of providing the necessary care to patients. Therefore, the development of new designs of dynamic transpedicular systems is an important socially significant problem, and their widespread adoption in practice will dramatically improve the quality of life of patients and avoid the need for reoperations.

2. INFORMATION

Since the 1940's a pedicle screw fixation have evolved and become increasingly popular among spine surgeons (Kabins, & Weinstein, 1991). This method provide immediate stability and rigid immobilization of the spine in local area (e.g. Luque, 1986; Harrington, & Dickson, 1976).

The using of traditional transpedicular systems in the treatment of adolescent scoliosis accompanied by three negative factors. Because the spine growth continues, on average up to 25 years with the passage of time or will be fractured spongy bone screw, or will be destroyed the vertebral bodies, or will be hindered of the spine growth. All this adduce to the need to perform extremely costly repeated surgical interventions, which are 3-5 times more expensive than primary. In addition, the durability of installed transpedicular system depend from change over time of the biomechanical strength of the spine elements, i.e. parameters determining the possibility of vertebral bodies in certain mechanical properties of bone tissues and their structural organization to withstand repeated cyclic loading corresponding to the human lifestyle. The biomechanical strength of the vertebral bodies correlated with the modulus of elasticity of bone structures, which is defined by four main factors:

1. The volumetric mineral density
2. The quantity and the condition of a collagen fibers
3. The architectonics of a bone tissue
4. The structural property of a substance of intervertebral discs.

In addition, the strength of the vertebral bodies and discs with the time vary depending on age, physical activity, the level of their location, the presence of pathological processes and many other factors (Haberland, 2009).

Analysis of these circumstances led to a clearer understanding of the need to develop multimodular dynamic transpedicular system with four degrees of freedom, which would have been able anatomically to adapt to changing conditions of loading system "implant-spine" (Fig. 1).

Fig. 1. Modules appearance of assembled dynamic transpedicular system

There are several designs of such systems, which have a number of significant shortcomings. The basis of such systems are flexible couplings, which are extremely complex in design, have a small range of adjustment that can not be used for a long time, with the active growth of the spine. The presence in the construction of couplings of the elastic elements of the production of company «Scient'X» increases the probability of failure of transpedicular system as a whole. The next step in the development of such structures can be regarded as the development of the company «Paradigm Spine» together with the company «Porshe», is consisting of a rod, which longitudinally fixed vertebral bodies with polyaxial transpedicular screws, and contain elements to ensure the mobility of the stabilized spinal segment. The obvious

drawback of this design is the ability to install it no more than in two levels and only when at one level it is necessary to restore normal mobility, but on the other - to form a bone block. Thus, such prototypes can not provide the desired dynamics of the spine as a whole.

Developed in the laboratory of biomechanics of the Sevastopol National Technical University the anatomically adapted new dynamic transpedicular system is intend to meet the challenges of the required parameters of the mobility of the stabilized spine with a device of the system to the increase growth of the spine and the possibility of installing the system on the required number of levels to ensure the mobility of each of them (Application number a2010 00 430 for a patent of Ukraine, MPK7 A61F2/32. Monoaksial transpedicular screw/Pashkov, E.V. et al.; applicant: Sevastopol National Technical University - 18.01.1910 priority. See Fig. 2).

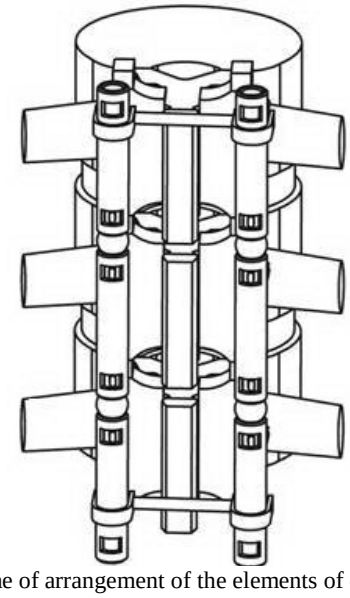

Fig. 2. Scheme of arrangement of the elements of dynamic transpedicular system for the lumbar spine (L3-L4-L5)

Due to the unique design of the transpedicular screw, which contains a truncated spherical head and the pattern of a hollow sleeve, the inner diameter is equal to the diameter of the spherical head of the transpedicular screws in a pair of "sleeve-screw" possibly a relative rotation of sleeve on the screw, which can be carried out in three dimensions, ie pair sleeve-screw has three rotational degrees of freedom.

In addition, a pair of "sleeve-screw" is also provided by the longitudinal degree of freedom than that established the possibility of change in the magnitude of the displacement variation of the length of the groove in the sleeve. The presence of these four degrees of freedom (Fig. 3) reduces the requirements for positioning accuracy of transpedicular screws when installed, thereby facilitating the installation of the system for transpedicular screws.

The presence of, for example, a hexahedron on neck transpedicular screw permit using a special key to turn it into a angle, needed for fixing the screw head in the sleeve, that is, eliminate the possibility of separation pair "sleeve-screw, which can occur in coincidence truncated spherical head the screw with longitudinal lateral surfaces of the groove bushings, through which the screw head is mated with the inner surface of the sleeve.

All this ensures the required parameters of the mobility of the stabilized spine and restore the natural architecture of the spine, with the same dynamic properties. The possibility of established a dynamic transpedicular system to adapt to changes in the size of the stabilized spinal segments, resulting from, for example, the growth of the spine in patients of child and teenage years, achieved due to the possibility of translational movement along the sleeve screw within the length of the slot through which the contacted pair "sleeve-screw ".

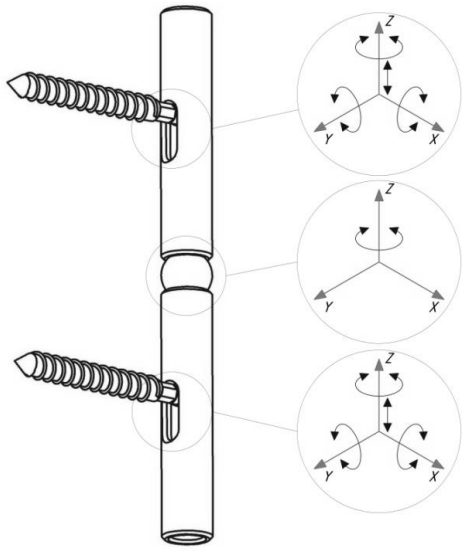

Fig. 3. Scheme of degrees of mobility elements of dynamic transpedicular system

In addition, it is possible changing size of displacement by varying the size of the groove. Simple design elements of the dynamic transpedicular system can change its length by the required amount by increasing the number of links in construction rod and change their size allows, if necessary, to establish a system with required number of levels on the spine with providing the required parameters of the mobility at each level.

3. CONCLUSION

The technology and design of high-tech new dynamic transpedicular system for the treatment of spinal diseases in children and adolescents are developed. The system allows for full functional recovery of the operated area of the spine and can be installed on any required levels. The presence of four degrees of mobility in the module of the system helps reduce stress in cells of the system and the spinal structures and helps to avoid repeated surgical interventions, which ultimately increases the quality of human life.

In the future are planned the clinical tests of this system and working out and research of similar system with elastic rods or their elements.

4. REFERENCES

Haberland, N. (2009). *Spinale navigation.* Pablishing hous of SevNTU, ISBN 978-966-2560-46-4, Sevastopol

Harrington, P. & Dickson, J. (1976). Spinal instrumentation in the treatment of severe progressive spondylolisthesis. *Clinical Orthopaedics & Related Research,* Vol.117, June, 157-163, ISSN**:** 0009-921X

Kabins, M. & Weinstein, J. (1991). The History of Vertebral Screw and Pedicle Screw Fixation. *Iowa Orthopaedics Journal,* Vol.11, 127-136, ISSN: 1541-5457

Luque, E. (1986). Interpeduncular segmental fixation. *Clinical Orthopaedics & Related Research,* Vol.203, February, 54-57, ISSN**:** 0009-921X

Prodan, A.; Radchenko, V. & Korzh, N. (2007). *Degenerative diseases of the spine*, STI “Contrast”, ISBN 978-966-8855-23-8, Kharkov