

Review of long-term results of anterior spondylodesis with different plasty applied for surgical treatment of spine injuries and diseases (literature review)

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The authors presented a retrospective review and current tendencies of anterior spondylodesis used to treat spine diseases and injuries. The review includes advantages and disadvantages offered by surgical bio-implants and implants made of ceramics, carbon fiber, titanium nickelide and other alloys. Combined application of metal and autologous bone was shown to be the common tendency of spine stabilization. The development of osteoinductive materials has become essential in spine fusion.

Keywords: anterior spondylodesis, implant, graft, osteoinductive material, bone morphogenetic protein

Recent literature on anterior spondylodesis as an isolated technique and combined with posterior stabilization and spine realignment indicated to the major operative practice used to treat unstable spine injuries and diseases.

In 1932, N. Capener, an English surgeon described the first anterior lumbar interbody fusion (ALIF) using bone autograft treating spondylolisthesis [1, 2]. V.D. Chaklin was the first surgeon who produced this surgery in the Soviet Union [3], and Ya.L. Tsivyan made the procedure popular in the country [4]. The priority of the method in operative treatment of vertebrogenic pathology persisted for a long time. However, application of implants and improved techniques resulted in a reassessment of ALIF as a stand-alone procedure to be used as a combined stage of surgical treatment with transpedicular screws. The combination allowed for realignment, decreased loading on an implant, and reduced time for patients to get ambulated. Titanium mesh cages as supporting non-resorption implants have been used widely for anterior fusion since 1986 when they first were introduced by Harms [5, 6]. Currently, implants produced from ceramics, carbon fiber, titanium nickelide and other titanium alloys have been made available to repair interbody defects and create favorable conditions to restore supporting function and provide stable spine fixation [5–7].

Repair of interbody defect can be performed with two methods. The first technology is aimed at enhancing the implant osteoconduction by creating ‘pores’ in the contacting surfaces of vertebral bodies and implants (titanium nickelide and carbon-carbon constructs). Another technique involves stabilizing implant (mostly, titanium mesh cages) to be filled with osteoinductive biological material like autologous bone or mineral bone plastic material [8, 9]. There are researches made to study an effect of calcium phosphorus products derived from bovine bone with organic matrix from bovine bone added to improve osteoinduction, as well as polypeptide growth factors derived from serum of animals with active osteogenesis, serum proteins. Comparison of different animal groups using radiological and optical density assessments showed efficient bone defect repair with application of calcium phosphorus products coupled with both organic matrix and serum proteins [10].

Of particular interest are inductors of bone regeneration enhancing regenerative bone potential due to demineralized bone matrix (DBM) that allows for retention of native growth factors BMP-2 and BMP-7 [11]. However, there are no reported data about the material applied for plasty of vertebral bodies.

The efficacy of stand-alone anterior lumbar in-

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terbody fusion in surgical treatment of true spondylolisthesis is questioned by some researchers. V.M. Shapovalov et al. reviewed long-term results of 47 patients with true spondylolisthesis treated with interbody wedging spondylodesis using bone graft. The authors revealed radiological spine instability in 18 (38.3 %) patients: 8 patients (17.1 %) developed instability at displacement level due to nonunited bone graft and vertebral bodies, and 10 patients (21.2 %) due to degeneration in the adjacent vertebral segments. Long-term follow-up (14 years and over) showed poor stand-alone ALIF outcomes in 12 (25.5 %) patients. 15 patients (31.9 %) were satisfied with the quality of life although they needed to take regular courses of conservative therapy, and 20 patients (42.6 %) showed a good level of physical activity and ability to work. Major reasons of poor long-term outcomes of surgical treatment of true spondylolisthesis included impaired stability (66.6 %) and spine balance (50 %), compression of neural and vascular elements of the spinal canal (33.3 %), progressive degenerative changes in adjacent vertebral segments (25 %), persisting degree of displaced vertebral body (25 %). The authors concluded that combination of transpedicular systems with spinal correction and ALIF was most practical for the treatment of this cohort of patients [1].

Baulin I.A. et al. produced radiological assessment of ALIF bone block at long-term follow-up [12, 13]. The technique used to treat 126 patients with infectious spondylitis showed several advantages of bone-filled mesh over autologous bone and stand-alone titanium mesh resulting in shorter fusion length without aggravation of infection, decrease in block height, kyphosis progression, and low rate of postoperative complications.

Stand-alone titanium mesh used for spondylodesis provides more favorable postoperative results. The authors concluded that the usage of bone-filled titanium mesh appeared to be optimal for anterior bone block at radical reconstructive procedure. Loss of spinal correction due to resorption of cortical edges was observed in the usage of bone autologous graft with no statistically significant differences in bone block formation.

Rerikh V.V. et al. reported progressing kyphosis with autologous bone graft at ventral spondy-

lodesis and higher efficacy of deproteinized bone graft at plasty of the broken vertebral body [14].

At the end of the 20th century there were international publications reporting complications of bone autoplasty [15–18]. Reported complications related to the donation of autogenous bone from the iliac crest included chronic pain, hematoma, infection, ventral herniation, fracture of the anterior superior iliac spine and impaired sensitivity at lateral cutaneous femoral nerve. The operating surgeon is considerably limited in a harvested graft size. Autogenous bone graft has the advantage of being accessible during the procedure and can provide better condition for regeneration and bone healing [19, 20].

Application of porous titanium nickelide implants is well established. Several authors showed efficient combined usage of titanium nickelide implants and bone autogenous grafts in repair of vertebral fractures of lower thoracic and lumbar spine [21]. V.V. Osintsev et al. reported long-term results of 101 patients with injuries to cervical spine and concluded that application of titanium nickelide implants provided earlier rehabilitation as compared to the usage of bone autogenous grafts [22]. Burlakov S.V. et al. made a comparative analysis in 2008 reviewing long-term results of anterior spondylodesis in infected spine treated with autogenous graft, titanium nickelide and carbon-carbon fiber implants and revealed only 67 % of bone block formation with autogenous graft [23]. Other patients developed such complications as broken graft, lesions and growing kyphosis. However, functional results showed no considerable differences in the two remaining groups regarding adaptation criteria. Most rewarding outcomes were observed in carbon-carbon fiber cases. Postresection defect appeared to be completely filled with newly formed regenerate bone in all the cases after 8 to 12 months. Iryanov Yu.M., Borzunov D.Yu., et al. conducted experimental study of osteointegration of porous titanium nickelide mesh and reparative bone regeneration with the implant [24]. The experiment involved simulated murine and canine tibial defect repaired with titanium nickelide mesh. Radiological assessment, scanning electronic microscopy and electron probe X-ray microanalysis showed osteogenesis and angiogenesis area with bone sheath formed around

the implant that indicated to biocompatibility and osteoinductive properties. Early osteointegration of the implant, regenerate bone remodeling and defect repair with lamellar bone tissue demonstrated long-term benefits of titanium nickelide mesh implants used in trauma and orthopaedics [24].

There are reported cases of structural allografts [14, 25, 26] used for anterior spondylodesis. Cancellous autogenous grafts are advocated to apply for allograft cavities to enhance osteoinductive properties. A successful application of interbody fusion with allografts and growth factors BMP-2 and BMP-7 resulted in consolidation rate of 99 % [27]. Cortical bone allografts harvested from humerus or femoral segments can be used for ventral lumbar fusion with multilevel surgery, in particular. The grafts are mechanically rather stable and are capable of covering at least two thirds of an endplate surface.

A.B. Makarov and K.S. Sergeev explored one of the most promising trends in vertebral bone defect repair using bioactive calcium phosphate based products, namely, hydroxyapatite (HA), with the structure very similar to human bone and with benefits of osteoinduction, osteoconduction and osteointegration [28–30]. Hydroxyapatite coatings on metal implants could provide a combination of high mechanical strength and bioactive properties. The authors compared effects of implants made of porous titanium nickelide and found that anterior interbody spondylodesis used

with mesh implant coated with nanostructured hydroxyapatite resulted in anatomic and functional restoration of injured vertebra reducing treatment length and rehabilitation of patients with comminuted thoracic and lumbar vertebrae. The findings showed effective application of hydroxyapatite coated implants for patients with low bone mineral density, osteoporosis and individuals at a higher risk for early osteoporosis [30, 31].

Several authors [7, 32] presented comparative data on ceramic and bone-ceramic implants, their characteristics, methods of production, their usage in medicine to improve osteogenesis with additional stimulating factors. V.V. Rerikh et al. showed effective application of porous bioceramic implants in ventral interbody fusion of low cervical spine in 3 cases [7]. With all apparent benefits of ceramics in spine surgery there are relatively few publications on the topic.

Current literature review has led us to conclude that there is a strong tendency towards interbody fusion techniques used in combination with metal and autobone. However, no gold standard surgical approach has been identified. Surgeons gradually refrain from stand-alone usage of bone allograft. Osteoinductive materials are another promising application in the spine surgery. Combined usage of bone grafts and BMP containing products might be practical for a bone block created without reinforcing metal constructs at the site of vertebral bone defect repair.

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