Neurospine 2020;17(1):111-113.
https://doi.org/10.14245/ns.2040126.063

Neurospine
pISSN 2586-6583 eISSN 2586-6591

Editorial

Commentary on “Biomaterials in Spinal Implants: A Review”

Hans-Joerg Meisel, Neha Agarwal

Department of Neurosurgery, Bergmannstrost Hospital, Halle, Germany

Corresponding Author
Hans-Joerg Meisel
E-mail: meisel@bergmannstrost.de
https://orcid.org/0000-0003-3838-1489

Department of Neurosurgery, BG Klinikum Bergmannstrost, Halle, Germany

See the article “Biomaterials in Spinal Implants: A Review” via https://doi.org/10.14245/ns.1938296.148.

In the current issue of *Neurospine*, Warburton et al.[1] reviewed the use of biomaterials in spinal implants focusing on their biocompatibility, mechanical characteristics, and real-world evidence. Clinical outcomes of spinal fusion surgery are correlated with the achievement of bony fusion. Other than the interbody fusion material, the stabilization and interbody screw fixation play an important mechanical role in restriction of motion and load-bearing. The most commonly used implants are metallic (titanium [Ti] or alloys) or polymers (polyetheretherketone, PEEK). To achieve best clinical outcomes, these must be combined with osteoconductive and osteoinductive materials. Ideally, a desired biomaterial implant will be which does not require additional allograft or autograft for fusion.

Most commonly used interbody cages are of Ti and its alloys and PEEK. When comparing Ti with PEEK, cage subsidence is higher in Ti cages, but rate of fusion is comparable between Ti and PEEK cages. PEEK in comparison to Ti has lower support for osteogenic tissues, hence lower level of bone integration.[2]

Studies have also reported pseudoarthrosis after anterior cervical discectomy and fusion (ACDF) which is correlated with the graft choice and is statistically significant with PEEK, polymethymethacrylate, and trabecular metal compared to autografts. In their systematic analysis Iunes et al.[3] also reported that Ti, zero profile, and carbon cages have lower incidence of pseudoarthrosis.

Attempts have been made to combine characteristics of Ti and PEEK for implants to achieve improved outcomes. Assem et al.[4] reported safety, efficacy, similar fusion rates and clinical outcomes of Ti/PEEK spinal fusion cages compared to standard PEEK cages. Various modifications of Ti and PEEK interbody device such as hydroxyapatite-coating, composites with calcium silicate, bioglass, and β-tricalcium phosphate are available but lack enough preclinical and clinical studies.

Implant made of other materials such as silicon nitride, Tantalum, Nitinol, and bioabsorbable cages are available but are supported by results from few clinical studies. A multicenter retrospective study for ACDF showed comparable clinical efficacy for silicon nitride cages compared to existing evidence for other cage implants.[5] Single level locking standalone cages for ACDF have been investigated by several groups and show similar clinical and radiological outcomes as anterior plate constructs. Stand-alone cages have been also associated with lower incidence of dysphagia and adjacent segment degeneration.[6]

There exist some contrary views for the tantalum implants for cervical fusions but for the lumbar fusions, trabecular metal has been demonstrated to obtain fusion and improved patient outcomes.[7] Ti and tantalum have also been shown to act as scaffold for mesenchymal stem cells *in vitro* and in animal studies which have clinical implications for spinal fusion and regenerative strategies.[8,9]

Of further interest will be the cages of Nitinol with shape memory and super elastic properties. A single retrospective cohort study indicates similar fusion rates with TiNi implant for lumbar surgeries compared with alternative cages.[10] Bio-absorbable cages are another generation of cages which can avoid artefacts on scans, reduce long term toxicity. The clinical studies support the use of bioabsorbable interbody devices for structural support.[11] However, bioabsorbable posterior lumbar instrumented fusion cages, showed high osteolytic nature in 44% of the patients in a case series.[12] Bioabsorbable screws and plates are available as well but again, there is paucity of statistically significant clinical evidence in favor of biodegradable implants over traditional instrumentation

When deciding on appropriate metal for rods, clinical evidence is not sufficient to favor single metal, and characteristics of each type of rod should be considered while choosing for spinal surgery. Rigid rods can cause adjacent segment disease and other adverse effects. Dynamic stabilization devices preserve motion but have high rate of implant failure and reoperation. A systematic review, reported lower incidence of adjacent segment disease with PEEK semirigid rods.[13] Nitinol has comparable wear resistance with CoCr and 100 times higher compared with Ti which makes Nitinol rods, stabilization system suitable for spinal instrumentation.[14] Memory rods have a special feature to return to their prebent shape on increase in temperature which would be particularly useful in scoliosis surgeries.

Artificial discs designed for disc replacement surgeries aim to mimic the characteristics of a natural disc. The ProDisc, activL Artificial disc, Charite, and Mobi-C implants have ultrahigh molecular weight polyethylene cores which provides them with low risk of free radical damage and lower friction. Success of another new generation M6 implant which has a polycarbonate urethane core providing a large degree of shock absorbance is yet to be clinically proven.[15] Tissue engineering approaches aiming at creating a scaffold which develop into similar structure as natural disc, are poised to decide the future of disc regeneration research.

Recently, 3-dimensional (3D) printing is in trend and being used for surgical planning, intraoperative surgical guides, patient specific and Off-The-Shelf surgical implants. The technology has a great potential to improve surgical implant characteristics, procedural accuracy, patient outcomes and reduce surgical time. The studies reporting 3D technology in spine are so far of low-quality with inherent bias and prevent from deriving a firm conclusion.[16]

Low grade of clinical evidence is available for certain implant materials, but evidence is particularly lacking for surface modifications of implant materials. The biomaterials in spinal surgeries merit further investigation. Today, spine surgeons have at their disposal many spine implants such as pedicle screws, hooks, rods, plates and interbody fusion devices to choose from. New biomaterials are introduced without analysis of clinical outcomes. Their indications and applications are still being explored, so the use should be cautious. Complete understanding of the material and their behavior in physiological conditions is important to allow its use as an implant for spinal diseases. Other than efficacy and clinical outcomes, cost-effectiveness should also be an important factor in the decision-making process.

REFERENCES

1. Warburton A, Girdler SJ, Mikhail CM, et al. Biomaterials in spinal implants: a review. Neurospine 2019 Nov 4 [Epub]. https://doi.org/10.14245/ns.1938296.148.
2. Seaman S, Kerezoudis P, Bydon M, et al. Titanium vs. polyetheretherketone (PEEK) interbody fusion: meta-analysis and review of the literature. J Clin Neurosci 2017;44:23-9.
3. Iunes EA, Barletta EA, Barba Belsuzarri TA, et al. Correlation between different interbody grafts and pseudarthrosis after anterior cervical discectomy and fusion compared with control group: systematic review. World Neurosurg 2020; 134:272-9.
4. Assem Y, Mobbs RJ, Pelletier MH, et al. Radiological and clinical outcomes of novel Ti/PEEK combined spinal fusion cages: a systematic review and preclinical evaluation. Eur Spine J 2017;26:593-605.
5. Calvert GC, Huffmon GV 3rd, Rambo WM Jr, et al. Clinical outcomes for anterior cervical discectomy and fusion with silicon nitride spine cages: a multicenter study. J Spine Surg 2019;5:504-19.
6. Nambiar M, Phan K, Cunningham JE, et al. Locking standalone cages versus anterior plate constructs in single-level fusion for degenerative cervical disease: a systematic review and meta-analysis. Eur Spine J 2017;26:2258-66.
7. Hanc M, Fokter SK, Vogrin M, et al. Porous tantalum in spinal surgery: an overview. Eur J Orthop Surg Traumatol 2016; 26:1-7.
8. Blanco JF, Sánchez-Guijo FM, Carrancio S, et al. Titanium and tantalum as mesenchymal stem cell scaffolds for spinal fusion: an in vitro comparative study. Eur Spine J 2011;20

 https://doi.org/10.14245/ns.2040126.063

Suppl 3:353-60.
9. Shi LY, Wang A, Zang FZ, et al. Tantalum-coated pedicle screws enhance implant integration. Colloids Surf B Biointerfaces 2017;160:22-32.
10. Abduljabbar FH, Makhdom AM, Rajeh M, et al. Factors associated with clinical outcomes after lumbar interbody fusion with a porous nitinol implant. Global Spine J 2017;7:780-6.
11. Coe JD. Instrumented transforaminal lumbar interbody fusion with bioabsorbable polymer implants and iliac crest autograft. Neurosurg Focus 2004;16:E11.
12. Frost A, Bagouri E, Brown M, et al. Osteolysis following resorbable poly-L-lactide-co-D, L-lactide PLIF cage use: a review of cases. Eur Spine J 2012;21:449-54.
13. Li C, Liu L, Shi JY, et al. Clinical and biomechanical researches of polyetheretherketone (PEEK) rods for semi-rigid lumbar fusion: a systematic review. Neurosurg Rev 2018;41:375-89.
14. Kim YS, Zhang HY, Moon BJ, et al. Nitinol spring rod dynamic stabilization system and Nitinol memory loops in surgical treatment for lumbar disc disorders: short-term follow up. Neurosurg Focus 2007;22:E10.
15. Othman YA, Verma R, Qureshi SA. Artificial disc replacement in spine surgery. Ann Transl Med 2019;7(Suppl 5):S170.
16. Wilcox B, Mobbs RJ, Wu AM, et al. Systematic review of 3D printing in spinal surgery: the current state of play. J Spine Surg 2017;3:433-43.

Title: Seated Woman
Artist: Pablo Picasso
Year: 1927