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Innovations in Orthopedic Surgery: How to Change Good to Perfect?

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Abstract

Innovation has always been an obvious part of orthopedic surgery. Orthopedics has been moving toward excellence through robotic surgeons, stem cell applications, scaffolds, and minimally invasive methods from a surgical branch that has already achieved good results thanks to plates, intramedullary nails, prostheses, and arthroscopy, which entered our daily practice in the last century.

Keywords: Stem cell, robotic surgery, humanization, scaffold

INTRODUCTION

Orthopedics is one of the departments where technological innovations and innovative technologies are frequently used. The wide range of operations starting from trauma-induced fractures in orthopedic surgery to arthroplasty or soft tissue reconstruction in sports surgery, and the patient portfolio starting from the newborn period to the old patients, always push the orthopedists to be innovative and perfectionist. When the high expectations of patients with fracture and elective surgical patients are added to this, it becomes a necessity for the orthopedics department to be a pioneer in adapting new technologies to medicine.

Unfortunately, the periods of war have become the periods when the most rapid developments occurred in orthopedics. The concepts of "antisepsis", "recurrent debridement", and "primary and delayed wound healing" that were put forward after the World War I (1), and the internal fixation methods that rapidly became popular after World War II, established the basis of modern orthopedics.

Minimally invasive procedures made a breakthrough in orthopedics, especially with the use of arthroscopy to view the knee joint 100 years ago in 1918, and with the popularization of arthroscopic methods after the 1950s (2).

Another important development in the last century was to find a solution to the hip and knee arthrosis seen in about half of the population, thanks to total hip and total knee prosthesis.

Compilation

We can say that orthopedic surgery is at a new turning point, especially with the introduction of tissue engineering and robotic surgery into the field of orthopedics after the 1990s.

With the use of three-dimensional printers in the medical field, orthopedic surgery shows a shift from being implant-based to being biological-based. Bone scaffolds of large bone defects that are formed in 3D printers are produced to provide a new bone tissue. However, in the recent years, the transformation rates of bone scaffold into original bone and knitting rates have considerably increased with the use of dipyridamole in the content of these scaffolds (3). This newly formed bone has the same durability and biological properties as the biomechanically undamaged bone has (4).

Another place where three-dimensional printers are used is polyurethanes- or collagen-based meniscus scaffolds developed for the patients who become symptomatic after simple meniscus injury, or whose complaints do not recover after arthroscopic meniscectomy, but who are not suitable

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for knee replacement. These implants have been in use since approximately 10 years, and they have proven to be useful in symptomatic patients after meniscectomy in large meta-analyses (5, 6). Studies suggest that the results of collagen-based meniscus implants are better (7). Thanks to these implants, patients who have completely lost the meniscus tissue can return to their normal daily lives with a simple arthroscopic procedure, and their need for prosthesis may be delayed.

Another important innovation in sports traumatology is the "humanized" animal ligaments. Many different graft alternatives have been used to prevent donor site morbidity, which is one of the difficulties during ligament reconstruction. However, the xenografts used until now caused swelling and early tendon re-ruptures due to the activation of the autoimmune system. Alternatively, allografts and synthetic grafts can be used. However, because of the low biocompatibility of synthetic grafts, the results are not satisfactory. The use of allografts was limited because their durability was low when they were not fresh-frozen, and their cost was high when they were fresh-frozen. However, the antigens in the xenografts obtained from pigs or cattle can be completely cleaned with the new "humanization" methods, and they do not produce autoimmune responses in the recipient (8). We expect that these animal-derived xenografts will soon be placed on orthopedic shelves. This humanization process can also be used to obtain animal-derived bone grafts for bone-based cancers such as osteosarcoma or for filling large bone defects developing secondary to trauma.

Large cartilage defects are one of the most important problems of joint surgery. Massive osteochondral allografts are currently the most popular methods for filling these defects. Instead of the use of massive osteochondral allografts, the use of these newly humanized shell xenografts with pluripotent stem cells was submitted for approval to the FDA in the US.

Grudon and Yamanaka won the Nobel Prize in the field of physiology and medicine in 2012 (9). They were able to obtain immature pluripotent stem cells by reprogramming somatic mature cells. This study is very close to eliminating ethical and cost problems such as obtaining the immature pluripotent stem cells from the cord blood or storing. In large cartilage defects of our degenerated joints, and in spinal cord injuries or degenerated intervertebral discs, stem cell therapies embedded in scaffolds that are taken from only a small skin biopsy and are programmed to be transformed into cartilage or nerve tissue again and are taken from 3D printers are the future of reconstructive orthopedics. Even today, stem cell applications are successfully used to create hyaline-like cartilage for cartilage defects. Stem cells obtained from adipose tissue or bone marrow aspiration are currently applied to the defect site with surgical methods. However, in the near future, the treatment with the stem cells delivered to the troubled region through selective arterial stem cell applications appears to be possible. Especially in avascular necrosis of the femoral head, studies show that stem cells given to the medial femoral circumflex artery feeding the femoral head stop the progression of the disease and provide near-total healing (10).

In spinal surgery, two important developments give hope for the future. The first of these is that Alpa-2-macroglobulin protein in the blood is able to inhibit the proteases that cause destruction of the disc in degenerative disc disease that affects millions of people in the world today (11). This finding will shed light on the development of new drugs and methods in the treatment of degenerative disc disease in the future. Another important development is the trial of elastic deformable plaques in spinal surgery. Especially the failure to provide fusion in cervical surgery constitutes a significant problem. Currently, 46% faster fusion can be achieved with these elastic plates in studies on animal models (12).

Although there are regulations in the field of materiology and tribology in prosthetic surgery every year, the actual innovation is the introduction of robotic navigation systems into prosthesis implantation. It has been shown that surgeons decrease the margin of error through the use of these navigation systems in centers where prosthesis surgery is not performed intensively, and thus they increase prosthetic survival (13, 14).

In addition to clinical benefits, robotic systems will also reduce the burden on the health-care system by reducing the transfer costs of patients and materials. The decreasing number of health personnel compared to the increasing and aging population every year will be insufficient to provide adequate health services. Orthopedists will soon be able to perform the surgery with distant connections and without even going to the hospital or possibly from a completely different country, and they will not need anything other than a few arms of the robot. Although it seems to be very futuristic at the moment, four to five sets of prostheses containers and a small pile that will be constituted by possible prosthesis sizes are required for a standard knee prosthesis operation, which increases both the inventory costs and hospitals' outgoings. A robotic system can do this only with one to two burr tips, and it can determine which size of an implant the patient will need before the operation. Data-tracking systems in these robotic systems will provide a wide range of patient data, and these data will contribute to the perfection of the technique and the training of next-generation surgeons (15).

The future of not only orthopedics but also medicine lies in the software. Thanks to the more intelligent computer softwares, the diagnosis of many diseases will be possible without the need for a doctor. For example, in the US, the FDA has approved the use of artificial intelligence in the detection of wrist fractures, and IBM has been working to develop this artificial intelligence software. In addition, companies such as Osso VR (USA) have introduced virtual reality simulations for the use in surgical training. These new softwares are evolving to provide a wide set of benefits ranging from the better adjustment of patient records and follow-up to the prevention of errors that could occur in nurse orders, and from the stock capabilities to the charging for services.

CONCLUSION

Although orthopedic surgery has come a long way with the widespread use of arthroplasty, internal bone fixation and arthroscopy in the last 100 years, it has reached a new milestone with the development of artificial intelligence, robotic surgeries, and stem-cell-based therapies.

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REFERENCES

1. Banovetz JM. The development of orthopedics in 20th century warfare. The Iowa Orthopaedic Journal 1997; 17: 32-46.
2. Jackson RW. From the scalpel to the scope: the history of arthroscopy. Baylor University Medical Center Proceedings 1996; 9: 77-9. [CrossRef]
3. Bekisz JM, Flores RL, Witek L, Lopez CD, Runyan CM, Torroni A, et al. Dipyridamole enhances osteogenesis of three-dimensionally printed bioactive ceramic scaffolds in calvarial defects. J Craniomaxillofac Surg 2018; 46: 237-44. [CrossRef]
4. Ishack S, Mediero A, Wilder T, Ricci JL, Cronstein BN. Bone regeneration in critical bone defects using three-dimensionally printed β-tricalcium phosphate/hydroxyapatite scaffolds is enhanced by coating scaffolds with either dipyridamole or BMP-2. J Biomed Mater Res B Appl Biomater 2017; 105: 366-75. [CrossRef]
5. Monllau JC, Poggioli F, Erquicia J, Ramírez E, Pelfort X, Gelber P, et al. Magnetic Resonance Imaging and Functional Outcomes After a Polyurethane Meniscal Scaffold Implantation: Minimum 5-Year Follow-up. Arthroscopy 2018; 34: 1621-7. [CrossRef]
6. Patel JM, Ghodbane SA, Brzezinski A, Gatt CJ Jr, Dunn MG. Tissue-Engineered Total Meniscus Replacement With a Fiber-Reinforced Scaffold in a 2-Year Ovine Model. Am J Sports Med 2018; 46: 1844-56. [CrossRef]
7. Houck DA, Kraeutler MJ, Belk JW, McCarty EC, Bravman JT. Similar clinicaloutcomes following collagen or polyurethane meniscal scaffold implantation: a systematic review. Knee Surg Sports Traumatol Arthrosc 2018; 26: 2259-69. [CrossRef]
8. Zaffagnini S, Grassi A, Marcheggiani Muccioli GM, Roberti Di Sarsina T, Raggi F, Benzi A, et al. Anterior cruciate ligament reconstruction with a novel porcine xenograft: the initial Italian experience. Joints 2015; 3: 85-90. [CrossRef]
9. Omole AE, Fakoya AOJ. Ten years of progress and promise of induced pluripotent stem cells: historical origins, characteristics, mechanisms, limitations, andpotential applications. Peer J 2018; 11: e4370. [CrossRef]
10. Mao Q, Jin H, Liao F, Xiao L, Chen D, Tong P. The efficacy of targeted intraarterial delivery of concentrated autologous bone marrow containing mononuclear cells in the treatment of osteonecrosis of the femoral head: a five year follow-up study. Bone 2013; 57: 509-16. [CrossRef]
11. Huang B, Chen J, Zhang X, Wang J, Zheng Z, Shan Z, et al. Alpha 2-Macroglobulin as Dual Regulator for Both Anabolism and Catabolism in the Cartilaginous Endplate of Intervertebral Disc. Spine 2018; 22: doi: 10.1097/BRS.0000000000002852. [CrossRef]
12. Ledet EH, Sanders GP, DiRisio DJ, Glennon JC. Load-sharing through elastic micro-motion accelerates bone formation and interbody fusion. Spine J 2018; 18: 1222-30. [CrossRef]
13. Goradia VK. Computer-assisted and robotic surgery in orthopedics: where we are in 2014. Sports Med Arthrosc Rev 2014; 22: 202-5. [CrossRef]
14. Marchand RC, Sodhi N, Bhowmik-Stoker M, Scholl L, Condrey C, Khlopas A, et al. Does the Robotic Arm and Preoperative CT Planning Help with 3D Intraoperative Total Knee Arthroplasty Planning? J Knee Surg 2018; 15: doi: 10.1055/s-0038-1668122. [CrossRef]
15. Parsley BS. Robotics in Orthopedics: A Brave New World. J Arthroplasty 2018; 33: 2355-7. [CrossRef]