Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 3
Open Access

Advances in Hip and Knee Surgery: A Comprehensive Review on Replacement Procedures

Adnan Essa Al kilabi,
Kufa Medical College ,
Asader Teaching Hospital, Alkufa University,
Iraq.
E-mail: dr.adnanessa@gmail.com

Cite this paper as: Adnan Essa Al kilabi, (2024) Advances in Hip and Knee Surgery: A Comprehensive Review on Replacement Procedures. *Frontiers in Health Informatics, 13* (3), 3091-3099

Abstract:

Recent advances in knee and hip arthroplasty have concentrated on enhancing results, decreasing problems, and extending the life of implants. This is a crucial and rapidly evolving area, and this study highlights some of the most intriguing trends and advancements in it. Ceramic hip resurfacing, tiny hip stems, cementless knee replacement, and the increased use of the dual mobility articulation for hip arthroplasty are all noteworthy advancements. New possibilities for more complex arthroplasty procedures have emerged as a result of developments in additive manufacturing and surface modification of joint replacements. Recent advances in knee and hip replacement surgery, such as robotic-assisted procedures, are quite intriguing. Recent increases in this technology's use are yielding data that will be useful in deciding whether this method should replace others as the future standard of care for knee and hip arthroplasty.

Keywords: Hip, Knee, surgery.

Introduction:

Total joint arthroplasty is a surgical procedure that effectively manages arthritis in the hips and knees. The goal of joint replacement surgery is to restore mobility without discomfort by removing the damaged joint and replacing it with new, synthetic components that mimic the natural structure of the joint. The main goals of hip and knee implant design and research in the last hundred years have been to improve implant fixation and decrease mechanical wear. Thanks to advancements in bearing surfaces and implant coatings, this method has shown to be very effective, with significantly more long-lasting results than what was available during the 1960s, when contemporary hip and knee arthroplasty first emerged. Improving implant survival is an ongoing effort due to a combination of factors, including a more active and longer-lived population, a shift towards joint replacement at a younger age, and other similar trends. Nevertheless, the most recent advancements in knee and hip arthroplasty implant technology have mostly focused on techniques to optimise implant location and imitate more natural kinematics in an effort to enhance patient outcomes. This study will focus on a few of the most noteworthy technical advancements in knee and hip arthroplasty, namely in the areas of implant design and assistive technologies.

Hip resurfacing

It may come as a surprise to think of hip resurfacing as a novel technique, since resurfacing implants have been utilised in different forms for more than 40 years (1). When it comes to treating hip arthritis, hip resurfacing surgery is an option to the more traditional hip replacement (2). The femoral bone stock is better preserved with hip resurfacings than with traditional complete hip arthroplasty. A more biomechanically stable joint is the outcome of the bigger femoral head articulation (3). Large metal-on-metal articulations had their benefits, but

also came at a cost; certain implants had high revision rates mainly because they produced metal debris that some patients had unpleasant responses to. Public opinion of hip resurfacing has taken a nosedive because to the rising revision rate.1 Nevertheless, research has shown that hip resurfacing, as opposed to traditional total hip arthroplasty, results in better functional outcomes and reduced dislocation rates for younger, more active patients (4, 5). Hip resurfacing with metal on metal is still a possibility for athletic men with bigger hips, but it's not recommended for men with smaller femoral heads and is never a good choice for women. So, innovative alternative bearing pairs for hip resurfacing have been the focus of recent breakthroughs. Using ceramic-on-ceramic or metal-on-polyethylene articulations are two innovative ways to tackle this problem.

Two ceramic hip resurfacings have entered the early stages of clinical studies. Embody Orthopaedic Limited's (London, UK) H1 ceramic non-porous non-cemented hip resurfacing is now being assessed in a multicenter observational research that started enrolling in September 2017 (6). The purpose of this follow-up research is to assess the prosthesis's effectiveness and safety after 10 years. The first device was implanted on the 24th of September 2018, although certification in the UK is still pending for MatOrtho's ceramic on ceramic ReCerfTM. The company is based in Leatherhead, Surrey, UK. Although there is a lack of early clinical data for either implant, cadaveric studies have examined the mechanical characteristics of the ReCerfTM arthroplasty and found that the innovative ceramic acetabular component and a regular metal component degrade at similar rates (7). This is comforting.

Concerns about squeaking and ceramic bearing brittleness persist, despite the fact that ceramic on ceramic articulations actually have good wear characteristics. Additionally, stress shielding — an undesirable decrease in bone density around the implanted ceramic implants — is a possibility (8). Hip resurfacing using metal on cross-linked polyethylene (MoX) was created by Derek McMinn to solve these possible problems. At least eighty-eight MoX resurfacings have been performed so far (9). Despite the potential increase in volumetric polyethylene wear, this articulation has the ability to minimise metal ion leakage and the stress shielding seen with stiffer acetabular components (10).

Resurfacing of the hip with a small stem

When compared to traditional complete hip replacement, hip resurfacing has the benefit of preserving femoral bone stock. Minimally invasive surgical procedures have grown in popularity, and metal-on-metal hip resurfacing has been on the decline. As a result, smaller femoral prostheses have been developed with the goals of preserving bone stock and loading the proximal femur in a more physiological way (12).

Systematic reviews and meta-analyses of the different implants have been problematic due to differences in mini-stem philosophies and designs (13). On the other hand, a systematic evaluation conducted by Lidder et al., which included fifteen trials, found that, with an average follow-up of twelve years, 98.6% of implants survived (14). Mini stems seem to have a steeper learning curve than traditional total hip arthroplasty because to factors such as the wide range of femoral neck canal diameters, the need of a secure press fit, and the consequently narrow margin for error in implant placement and surgical technique. Enter text by clicking or tapping here (15). A randomized research investigating the durability of small stem implants after 2 years with radiostereometric analysis showing femoral component migration equivalent to regular length stems is only one example of the continuous evaluation of tiny stems (16).

A complete hip replacement procedure: dual mobility

Although Gilles Bousquet first created dual mobility articulations in 1974, they have recently seen increased application in primary total hip arthroplasty (10). The acetabular component of a joint replacement is articulated with a larger polyethylene head that contains a smaller metal or ceramic head that is contained yet moveable. A dual mobility implant describes this kind of design. The use of Dual Mobility articulations has increased in many national joint registries. The latest numbers from the American Joint Replacement Registry show that Dual Mobility is currently included into 6.9% of all total hip arthroplasties (19). One current school of thought maintains that dual mobility articulations ought to be accessible to everybody, not only the wealthy (20). Given the well-established and positive improvement in stability associated with a dual mobility articulation, the

increasing focus on the significance of unfavourable spinopelvic mobility and its impact on total hip arthroplasty stability may be driving the trend towards its more frequent use. Their use has also increased among the most vulnerable populations, including those with neuromuscular diseases or cognitive impairment (21). On the other hand, there is a lack of information on long-term survivability, issues with volumetric polyethylene wear, and intraarticular dislocations.Enter text by clicking or tapping here.22 In terms of wear rates, the current retrieval experiments have been encouraging (23,24).

Due to their enhanced stability, dual mobility articulations may also be used in revision surgery. In addition to their higher survivability compared to fixed-bearing implants, they have been used effectively for femoral alone revision of big head metal on metal hip arthroplasty and for alternate revision reasons using dual mobility articulations (25, 26).

Total knee replacement without cement

The creation of cementless fixation techniques has been one of the most encouraging aspects of knee arthroplasty implant development. Total knee arthroplasty prostheses have traditionally relied on polymethyl methacrylate cement, a kind of grout, to interdigitate the implant surface with the cancellous bone. Because there is no extra interface with cementless total knee arthroplasty, wear and loosening might be delayed. Nevertheless, there was a significant incidence of early failure in the first press fit designs, with a study showing an aseptic loosening rate of 8% after an average of 11 years of follow-up. Enter text by clicking or tapping here (27, 28). Technological and design developments in cementless materials have allowed for the creation of a new class of total knee arthroplasty implants. A recent randomised experiment documented data from an early follow-up analysis that compared patients with cementless implants to those with cemented implants. When it came to patient-reported outcome ratings and subsidence degree after two years, both were comparable. The operating time for cementless implants was shown to be shorter. Important exclusion criteria were patients' ages 75 and over, BMIs more than 40 kg/m2, and the presence of obviously osteoporotic bone or other bone abnormalities (29). Although studies utilised very limited inclusion criteria, a meta-analysis of cementless knee arthroplasty included 7 trials with an average follow-up of 6 years indicated favourable outcomes for survivability (30). Research on cementless knee arthroplasty implants has been limited in its scope, making it impossible to generalise about the technology's suitability (31).

The knee is one area where cementless technology has shown promise. There has been little cause for worry about osseointegration with the Oxford® cementless partial knee replacement from Zimmer Biomet (Warsaw, Indiana, USA), which has shown outstanding survival (32,33).

There was a lot of lysis and bone loss among younger patients who had cementless knee replacements because of the early designs' high failure rates (7).

Alterations to the outside of implants

In the field of prosthetic joints, innovations in implant design often take the stage. Nevertheless, a new approach to implant design has emerged that shows promise, since the problem of prosthetic joint infection continues to rise and osseointegration is being sought for.

Joint replacements are made from a variety of materials, although recent developments in surface modification have mostly targeted titanium. Due to its excellent biomechanical qualities and tolerance to surface alteration, titanium alloy—typically Ti-6Al-4V—finds extensive usage in orthopaedics (34). By promoting bone ongrowth or ingrowth, topographical alterations seek to enhance osteointegration. Surface coatings applied by plasma or grit blasting are examples of microscale roughening processes employed by these methods (35).

The possible consequences of nanoscale surface topography have prompted the creation of methods to alter the surface topography at a far smaller scale. Some of these procedures, including anodization and electron beam lithography, may make the implant surface more conducive to osteoconduction and, by extension, osteointegration, by producing nanoscale tubes, pits, pores, and pillars.

In addition to facilitating osteointegration, nanoscale surface alteration may influence the interaction of bacterial pathogens with the implant, which might reduce the catastrophic effects of prosthetic joint infection (36-38). An attractive strategy has emerged since the negative impact of biofilms linked to bacterial infection was identified: the modification of implant surfaces via nanotopographic patterns or the elution of bactericidal ions like silver(39). Research has shown that some bacterial species, which account for more than half of all prosthetic joint infections, may have their adherence reduced by modifying a titanium surface nanostructure (40). In the perioperative period, antibiotics are most effective when they prevent bacterial adhesion, which in turn reduces early bacterial colonisation, makes immune system evasion more difficult, and prolongs the life of the antibiotics. Alluding to the fact that many natural surfaces have evolved strategies to decrease bacterial colonisation over millennia, the procedures have taken cues from nature (41). Thus, scientists have taken elements from shark skin and dragonfly wings and scaled them down to the nanoscale; the result is a bacteriocidal wing with a self-cleaning surface that reduces bacterial adherence(42) .

Altering the surface texture of the implant isn't the only option; engineering the implant to release chemicals with antibacterial characteristics is another. Nanoparticles of silver have been the subject of the greatest research. Results showed that these implant-derived antimicrobial nanoparticles inhibited the growth of Staphylococcus aureus and Escherichia coli for as long as ten days in an in vitro setting (43). Nanoparticle elution and local tissue toxicity are, nevertheless, topics of considerable concern. Megaprosthetic substitutes for revision joint replacement or sarcoma surgery may be the first recipients of these technologies while they undergo risk and benefit assessments in the R&D phase (44).

Custom implants and additive manufacturing

For the most part, patients are happy with the results of joint replacements that use "off the shelf" components. With the ability to personalise implants, a tailored solution for knee and hip joint replacement is now within reach. This kind of individualised strategy is probably unnecessary for the vast majority of arthroplasty situations. A more involved revision procedure involving significant bone loss, tumour removal, or surgery after a severe injury could all benefit from this approach. It is anticipated that the level of personalisation of implants will increase as technology continues to progress and the cost of individual implants decreases (45).

In order to lessen stress shielding and more precisely restore the joint centre of rotation, total hip arthroplasty femoral implant customisation seeks to enhance the fit between the native anatomy and the implant. In the past, implants were coated to promote osteointegration after being created using conventional Computer Numerical Control (CNC) machining and tailored from standard radiographs. In a study published by Muirhead-Allwood et al. in 2010, they found that a series of tailored hip replacements had a survivability rate of 98.2% at 13.2 years. These stems were considered to be on par with the finest conventional femoral components (46). Dessyn et al. recently presented a series of 232 hip replacements with a 96.6% survivability rate in a younger group of patients, and they also showed satisfactory follow-up after 20 years (47).

Porous materials with varying density and stiffness to limit bone loss and remodelling owing to stress shielding may now be more easily produced using newer additive manufacturing processes. These implants are complicated and tailored to each patient's needs.48 out of 49 When it comes to acetabular revision surgery, most people's experiences with bespoke additive produced implants are negative. According to a new analysis by Martino et al., who looked at 17 trials on the topic of bespoke triflange acetabular components, the overall complication rate was 29%, with infection coming in at 6% and dislocation at 11% (50). With an average follow-up of 57.4 months, 3.1% of the 579 hips included in the study had aseptic loosening. The results in these difficult instances were on par with those of other reconstructive methods. It should be kept in mind that these implants cannot provide a track record because of their personalised character, even if these bespoke treatments often offer an attractive choice for difficult circumstances. To ensure that conventional joint replacements are still safe and effective and to serve as a baseline for more recent implants, the Orthopaedic Data Evaluation Panel (ODEP) has been monitoring their results since 2002. Patients should be informed by their surgeons that

statistics on survival is not available for bespoke implants, and these ratings will not be provided.

The use of robotics in surgical procedures

During knee and hip replacement surgeries, the intraoperative location of components has traditionally been determined using reference jigs and anatomical landmarks. Exciting new developments in joint arthroplasty include robotic-assisted hip and knee arthroplasty, which enhances the surgeon's capacity to make these important decisions. Systems for robotically assisted joint replacement surgery first became accessible in the 1980s (51). The use of computers to guide the placement of tools and implants during guided joint replacement surgery has given rise to robotic aided surgery, an advancement in this field. In robotic surgery, this is taken to the next level by having the robot move instruments into place or regulate their operation to make sure the bone excision goes according to plan. A patient's CT scan or, more recently, "image-free" methods that connect the patient's peri-operative anatomical landmarks to a database of joint morphologies are both viable options for basing the surgical plan on the patient's own anatomy. The use of robotic assistants has skyrocketed in the last decade, especially in the United States. Just over 5% of all hip and arthroplasty surgeries in the New York area between 2008 and 2015 were helped by robots or navigation (51).

In both knee and hip arthroplasty procedures, there is strong evidence that robotic-assisted surgery may increase the accuracy of implant placement in comparison to manual placement. In a case series of 100 patients, researchers (50,53) showed that using robotic guidance significantly improved acetabular component placing within 5° of the desired alignment compared to traditional procedures. When comparing robotic assistance to manual placement, researchers (51,54) discovered that both methods significantly improved the accuracy of acetabular component placement for total hip arthroplasty.
A randomised controlled trial including 120 patients found that robotic-assisted surgery for unicompartmental knee replacement enhanced implant insertion accuracy compared to conventional methods (55) A number of other studies have shown that robotic aided surgery may increase the precision of implant positioning for both total and unicompartmental knee replacements (56-59). When using a gap balancing procedure in knee arthroplasty, tensioning devices might be used as robotic aid to guarantee precise ligament balance (60). Obviously, robotic assistance may aid surgeons in accomplishing a certain goal; but, are there any further advantages? According to a study by Bukowski et al., who compared 100 robotic-assisted complete hip arthroplasties with 100 manual total hip arthroplasties, the former resulted in less blood loss and better functional success ratings (61). When compared to manual procedures, robotic assistance in total knee arthroplasty is safer for soft tissues (62). On the other hand, at this time, there is insufficient evidence to conclude that robotic-assisted surgery produces better functional results. When comparing the functional results of robotic-assisted knee and hip arthroplasty with those of manual surgery, Karunaratne et al. found no difference (after 14 trials) (63). The included trials were all of very low quality, and none of them improved patients' pain, quality of life, or satisfaction after surgery. Functional outcomes, revision rate, and range of motion were not different between robotic-assisted unicompartmental knee replacement and manual operations in a meta-analysis by Zhang et al. (64).

Extra expenses for robotic-assisted surgery include hardware, operating room time, and radiology-related expenditure for image-guided systems. The lack of proven therapeutic value so far has made cost-effectiveness an obstacle to its widespread implementation. Unicompartmental knee replacement may be more cost-effective in high-volume facilities that use robotic-assisted surgery, according to several research (51,65). The question of whether robotic-assisted surgery should be regarded as the benchmark for knee and hip arthroplasty remains unanswered.

Conclusion:

In this study, we have looked at some of the most interesting new approaches to knee and hip arthroplasty, as well as how our knowledge of robotics for joint replacement is expanding. While each of these innovations addresses a different facet of joint arthroplasty, they all work towards the same goal: better results for patients.

It is acknowledged that innovation is important, but it must not overshadow the crucial function of physicians in safeguarding patients from the possible negative consequences of new technology being introduced to the market without first undergoing thorough examination. Until this evaluation is finished, which usually takes the shape of carefully planned and evaluated clinical trials, surgeons should resist the inclination to try out cutting-edge technical discoveries. Because of the concept of diminishing returns and the high success rate of joint replacement procedures, new innovations will need to provide compelling evidence of long-term benefits before they can replace more established technologies.

References:

1. Amstutz HC, Duff MJL. Hip resurfacing: history, current status, and future. Hip Int J Clin Exp Res Hip Pathology Ther 2015; 25: 330–338.

2. De Smet KA, Pattyn C, Verdonck R. Early results of primary Birmingham hip resurfacing using a hybrid Metal-On-Metal couple. Hip Int 2002; 12: 158–162.

3. Su EP. Hip resurfacing: for the right patient and surgeon. Seminars Arthroplast 2016; 27: 239–243.

4. Oxblom A, Hedlund H, Nemes S, et al. Patient-reported outcomes in hip resurfacing versus conventional total hip arthroplasty: a register-based matched cohort study of 726 patients. Acta Orthop 2019; 90: 1–10.

5. Haddad FS, Konan S, Tahmassebi J. A prospective comparative study of cementless total hip arthroplasty and hip resurfacing in patients under the age of 55 years. Bone Joint J 2015; 97-B: 617–622.

6. Cobb JP, Clarke SJ, Jeffers J, et al. Anatomic ceramic hip resurfacing arthroplasty: first in human trials. Orthopaedic Proceedings 2018; 100-B: 29–29.

7. Farrier AJ, Moore L, Manning W, et al. Comparing the cup deformation following implantation of a novel ceramic-on-ceramic hip resurfacing bearing to a metal standard in a cadaveric model. Proc Inst Mech Eng H 2019; 233: 603–610.

8. Su EP. Ceramic-Ceramic bearing: Too unpredictable to use it regularly. Hss J 2012; 8: 287–290.

9. Treacy RBC, Holland JP, Daniel J, et al. Preliminary report of clinical experience with metal-on-highly-crosslinked-polyethylene hip resurfacing. Bone Joint Res 2019; 8: 443–450.

10. Jones CW, De Martino I, D'Apolito R, et al. The use of dual-mobility bearings in patients at high risk of dislocation. Bone Joint J 2019; 101-B: 41–45.

11. Tatani I, Panagopoulos A, Diamantakos I, et al. Comparison of two metaphyseal-fitting (short) femoral stems in primary total hip arthroplasty: study protocol for a prospective randomized clinical trial with additional biomechanical testing and finite element analysis. Trials 2019; 20: 359.

12. Stulberg SD, Patel RM. The short stem. Bone Joint J 2013; 95-B: 57–62.

13. Feyen H, Shimmin AJ. Is the length of the femoral component important in primary total hip replacement? Bone Joint J 2014; 96-B: 442–448.

14. Lidder S, Epstein DJ, Scott G. A systematic review of short metaphyseal loading cementless stems in hip arthroplasty. Bone Joint J 2019; 101-B: 502–511.

15. Pairon P, Haddad FS. Stem size in hip arthroplasty. Bone Joint J 2018; 100-B: 1133–1135.

16. Ferguson RJ, Broomfield JA, Malak TT, et al. Primary stability of a short bone-conserving femoral stem. Bone Joint J 2018; 100-B: 1148–1156..

17. Fessy M-H. La double mobilité. Revue De Chir Orthopédique Et Traumatologique 2010; 96: 891–898.

18. Mertl P, Combes A, Leiber-Wackenheim F, et al. Recurrence of dislocation following total hip

arthroplasty revision using dual mobility cups was rare in 180 hips followed over 7 years. Hss J Musculoskelet J 2012; 8: 251–256.

19. Heckmann N, Weitzman DS, Jaffri H, et al. Trends in the use of dual mobility bearings in hip arthroplasty: an analysis of the american joint replacement registry. Bone Jt J 2020; 102-B: 27–32.

20. Blakeney WG, Epinette J-A, Vendittoli P-A. Dual mobility total hip arthroplasty: should everyone get one? Efort Open Rev 2019; 4: 541–547.

21. Rivière C, Lazennec J-Y, Straeten CVD, et al. The influence of spine-hip relations on total hip replacement: a systematic review. Orthop Traumatol Surg Res 2017; 103: 559–568. Crossref.

22. Plummer DR, Haughom BD, Valle CJD. Dual mobility in total hip arthroplasty. Orthop Clin North Am 2014; 45: 1–8. Crossref.

23. Boyer B, Neri T, Geringer J, et al. Long-term wear of dual mobility total hip replacement cups: explant study. Int Orthop 2018; 42: 41–47.

24. Tarity TD, Koch CN, Burket JC, et al. Fretting and corrosion at the backside of modular cobalt chromium acetabular inserts: a retrieval analysis. J Arthroplasty 2017; 32: 1033–1039.

25. Chan MK, Caudwell M, Suchowersky A, et al. Femoral side-only revision options for the Birmingham resurfacing arthroplasty. Anz J Surg 2019; 89: 1016–1021.

26. Harwin SF, Sultan AA, Khlopas A, et al. Mid-Term outcomes of dual mobility acetabular cups for revision total hip arthroplasty. J Arthroplasty 2018; 33: 1494–1500.

27. Berger RA, Lyon JH, Jacobs JJ, et al. Problems with cementless total knee arthroplasty at 11 years followup. Clin Orthop Relat R 2001; 392: 196–207.

28. Nafei A, Nielsen S, Kristensen O, et al. The press-fit kinemax knee arthroplasty. High failure rate of non-cemented implants. J Bone Jt Surg Br Volume 1992; 74-B: 243–246.

29. Nam D, Lawrie CM, Salih R, et al. Cemented versus cementless total knee arthroplasty of the same modern design. J Bone Joint Surg Am 2019; 101: 1185–1192.

30. Newman J, Sodhi N, Dekis J, et al. Survivorship and functional outcomes of cementless versus cemented total knee arthroplasty: a meta-analysis. J Knee Surg 2020; 33: 270–278. 10.1055/s-009-1678525.

31. Evans JT, Walker RW, Evans JP, et al. How long does a knee replacement last? a systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow-up. Lancet 2019; 393: 655–663.

32. van der List JP, Sheng DL, Kleeblad LJ, et al. Outcomes of cementless unicompartmental and total knee arthroplasty: a systematic review. Knee 2017; 24: 497–507.

33. Mohammad HR, Kennedy JA, Mellon SJ, et al. Ten-year clinical and radiographic results of 1000 cementless Oxford unicompartmental knee replacements. Knee Surg Sports Traumatology Arthrosc 2019; ▪: 1–9.

34. Guillemot F. Recent advances in the design of titanium alloys for orthopedic applications. Expert Rev Med Devices 2005; 2: 741–748.

35. Ramaswamy Y, Wu C, Zreiqat H. Orthopedic coating materials: considerations and applications. Expert Rev Med Devices 2009; 6: 423–430.

36. Campoccia D, Montanaro L, Arciola CR. A review of the biomaterials technologies for infection-resistant surfaces. Biomaterials 2013; 34: 8533–8554.

37. Gbejuade HO, Lovering AM, Webb JC. The role of microbial biofilms in prosthetic joint infections.

Acta Orthop 2015; 86: 147–158.

38. Chouirfa H, Bouloussa H, Migonney V, et al. Review of titanium surface modification techniques and coatings for antibacterial applications. Acta Biomater 2019; 83: 37–54.

39. Costerton JW. Biofilm theory can guide the treatment of Device-Related orthopaedic infections. Clin Orthop Relat R 2005; 437: 7–11.

40. Puckett SD, Taylor E, Raimondo T, et al. The relationship between the nanostructure of titanium surfaces and bacterial attachment. Biomaterials 2010; 31: 706–713.

41. Bhadra CM, Truong VK, Pham VTH, et al. Antibacterial titanium nano-patterned arrays inspired by dragonfly wings. Sci Rep 2015; 5: 16817.

42. Levack AE, Cyphert EL, Bostrom MP, et al. Current options and emerging biomaterials for periprosthetic joint infection. Curr Rheumatol Rep 2018; 20: 33.

43. Pishbin F, Mouriño V, Gilchrist JB, et al. Single-step electrochemical deposition of antimicrobial orthopaedic coatings based on a bioactive glass/chitosan/nano-silver composite system. Acta Biomater 2013; 9: 7469–7479.

44. Sullivan MP, McHale KJ, Parvizi J, et al. Nanotechnology. Bone Jt J 2014; 96-B: 569–573.

45. Trauner KB. The emerging role of 3D printing in arthroplasty and orthopedics. J Arthroplasty 2018; 33: 2352–2354.

46. Muirhead-Allwood S, Sandiford N, Skinner JA, et al. Uncemented custom computer-assisted design and manufacture of hydroxyapatite-coated femoral components. J Bone Joint Surg Br 2010; 92: 1079–1084.

47. Dessyn E, Flecher X, Parratte S, et al. A 20-year follow-up evaluation of total hip arthroplasty in patients younger than 50 using a custom cementless stem. Hip Int 2018; 29: 112070001880329.

48. Murr LE, Gaytan SM, Martinez E, et al. Next generation orthopaedic implants by additive manufacturing using electron beam melting. Int J Biomater 2012; 2012: 245727.

49. Arabnejad S, Johnston B, Tanzer M, et al. Fully porous 3D printed titanium femoral stem to reduce stress-shielding following total hip arthroplasty. J Orthop Res 2017; 35: 1774–1783.

50. Martino ID, Strigelli V, Cacciola G, et al. Survivorship and clinical outcomes of custom triflange acetabular components in revision total hip arthroplasty: a systematic review. J Arthroplast Epub ahead of print 2019; 10.1016/j.arth.2019.05.032.

51. Clement ND, Deehan DJ, Patton JT. Robot-assisted unicompartmental knee arthroplasty for patients with isolated medial compartment osteoarthritis is cost-effective. Bone Joint J 2019; 101-B: 1063–1070.

52. Chai W, Guo R, Puah KL, et al. Use of robotic-arm assisted technique in complex primary total hip arthroplasty. Orthop Surg 2020; 12: 686–691.

53. Lawson JA, Garber AT, Stimac JD, et al. Does robotic-assisted total hip arthroplasty improve accuracy of cup positioning? J Hip Surg 2019; 03: 176–180.

54. Illgen RL, Bukowski BR, Abiola R, et al. Robotic-Assisted total hip arthroplasty: outcomes at minimum two-year follow-up. Surg Technology Int 2017; 30: 365–372.

55. Bell SW, Anthony I, Jones B, et al. Improved accuracy of component positioning with robotic-assisted unicompartmental knee arthroplasty. J Bone Jt Surg 2016; 98: 627–635. Crossref.

56. Lonner JH, Fillingham YA. Pros and cons: a balanced view of robotics in knee arthroplasty. J Arthroplasty 2018; 33: 2007–2013.

57. Rahman J, Al-Tawil K, Khan WS. General principles of. Orthopedics and Trauma 2019; ▪: 629–637.

58. Volpin A, Maden C, Konan S. 23 New advances in robotic surgery in hip and knee replacement. Handb Robotic Image-Guided Surg 2020; ▪: 397–410.

59. Hampp EL, Chughtai M, Scholl LY, et al. Robotic-Arm assisted total knee arthroplasty demonstrated greater accuracy and precision to plan compared with manual techniques. J Knee Surg 2019; 32: 239–250.

60. Shalhoub S, Lawrence JM, Keggi JM, et al. Imageless, robotic-assisted total knee arthroplasty combined with a robotic tensioning system can help predict and achieve accurate postoperative ligament balance. Arthroplast Today 2019; 5: 334–340.

61. Bukowski BR, Anderson P, Khlopas A, et al. Improved functional outcomes with robotic compared with manual total hip. Arthroplasty Surg Technology Int : XXIX.

62. Sultan AA, Piuzzi N, Khlopas A, et al. Utilization of Robotic-Arm assisted total knee arthroplasty for soft tissue protection. Expert Rev Med Devices 2017; 14: 925–927.

63. Karunaratne S, Duan M, Pappas E, et al. The effectiveness of robotic hip and knee arthroplasty on patient-reported outcomes: a systematic review and Meta-analysis. Int Orthop 2019; 43: 1283–1295.

64. Zhang F, Li H, Ba Z, et al. Robotic arm-assisted vs conventional unicompartmental knee arthroplasty: a Meta-analysis of the effects on clinical outcomes. Medicine 2019; 98: e16968.

65. Moschetti WE, Konopka JF, Rubash HE, et al. Can Robot-Assisted unicompartmental knee arthroplasty be Cost-Effective? a markov decision analysis. J Arthroplast 2016; 31: 759–765.