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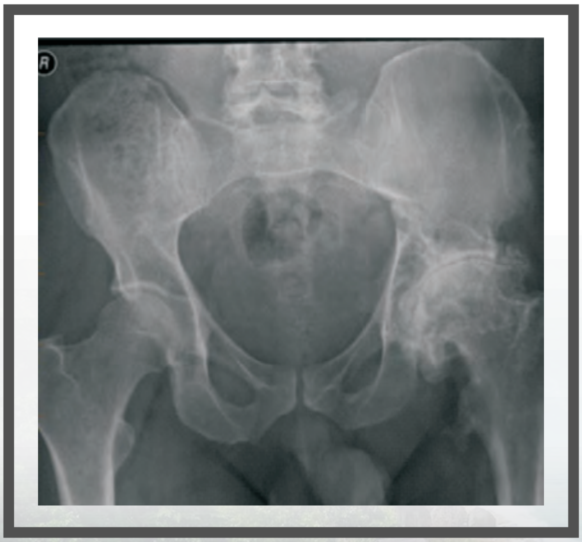

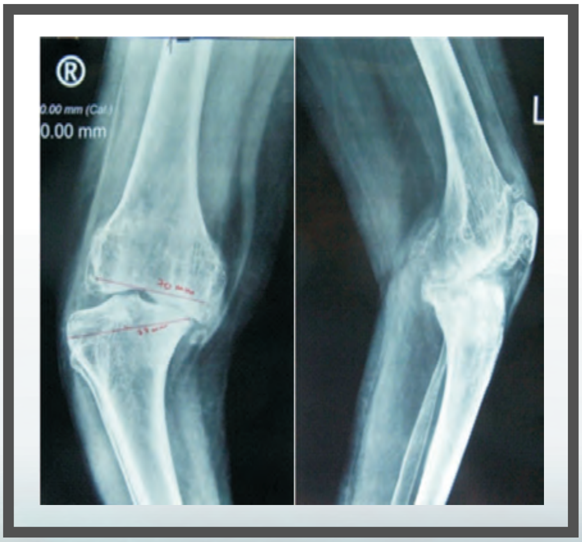

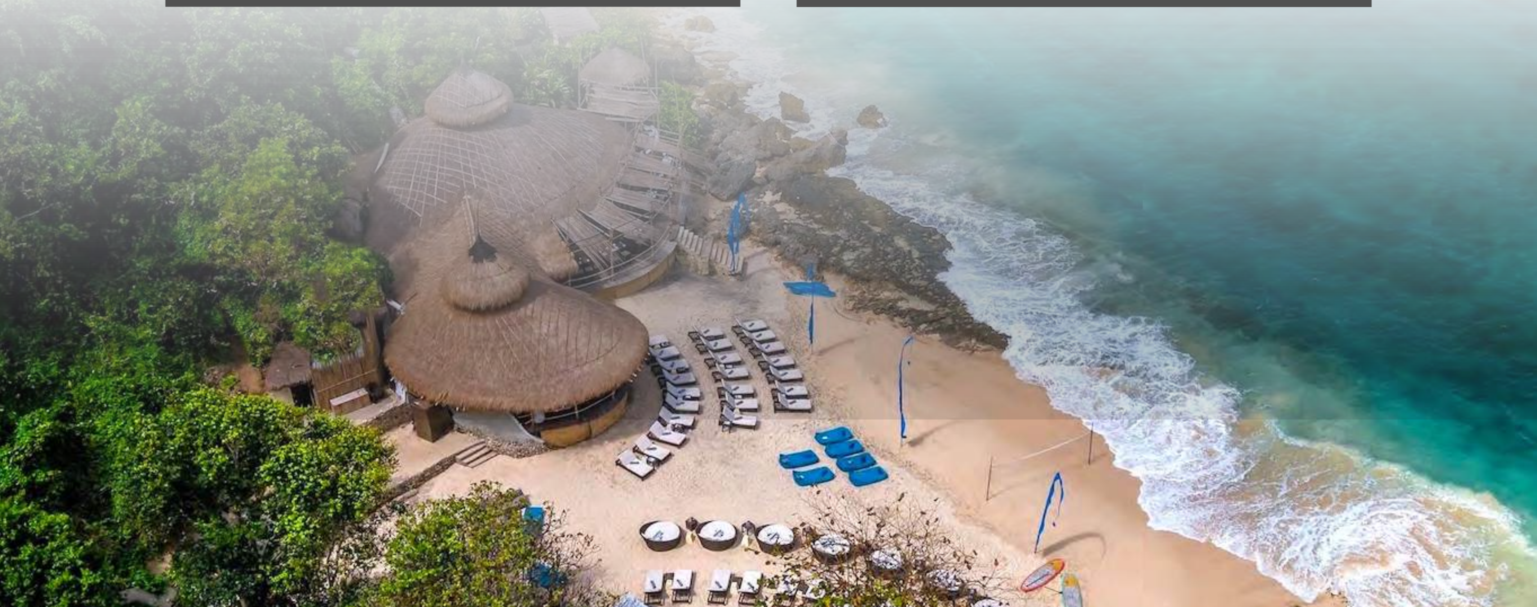

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Edited by *Dr Rajeev K Sharma*

Message from the President

"Vision 2021 and beyond"

A/Prof Nicolaas C. Budhiparama

Welcome to APAS Newsletter issue 4!

The year 2020 has been a tough year for everyone worldwide due to the global pandemic. Lifestyles and working habits are severely affected. We, as arthroplasty surgeons, see a sudden cessation of all practices and surgeries beginning in March 2020 for at least a couple of months. After COVID-19 protocols have been implemented, we see a resume of trauma and revision surgeries with a few urgent knees and hip replacements in between.

The importance of social distancing, protective gear, and COVID-19 testing took off to another level. Almost all face-to-face meetings were canceled or postponed,or replaced with virtual meetings. I assumed the Presidency of APAS during one of these virtual meetings in August 2020. Since then, APAS has moved forward with a new and larger Board of Committees with some exciting plans of online education, fellowship, and young surgeons' forum. APAS had run a series of debates on controversial topics in collaboration with other partner societies and OrthoTV to reach a wider audience worldwide. We plan to accept applications for our traveling fellowship program later this year, exclusive for our members. This traveling fellowship program, which was put on hold due to the pandemic, will resume in 2022 once the travel restrictions have been lifted.

The COVID-19 vaccine rollout is another obstacle to overcome in 2021, deciding which vaccine to use and people's resistance to getting vaccinated. While countries like the US have vaccinated millions of people, some other countries may not have access to a vaccine. News of vaccine side effects or vaccinated people still tested positive does not help the progress we hope to achieve. With such slow progress of virus eradication, we expect the pandemic to last at least another year, leaving us with no choice but to bear with the travel restrictions. It seems that online education will remain in the near future, so collaborations among societies will help reach more audiences. Considering the current situation, it is unlikely to have an in-person meeting as planned in Bali. We have, unfortunately, postponed the meeting to August 2022. Instead, we plan to have a webinar with the regular renowned faculty planned for the second half of this year. We will post updates on the website as they become available.

Beyond 2021, as we resume our regular activities, I see technology continue to be at the forefront of medical development. Innovation such as robotic-assisted surgery and artificial intelligence to process large quantities of data to help predict outcomes or help physicians with decision-making will continue to be studied. Still, please bear in mind that no new technology should be adopted without prior evaluation.

So, go forth and learn more about APAS while always keeping safe and healthy.

Sincerely Yours,

A/ Prof. Nicolaas C. Budhiparama, MD., Ph.D.
(President of APAS 2020 - 2022)

10 LESSONS LEARNED FROM COVID PANDEMIC

Prof. Parag Sancheti *Dr Ashok Shyam*

We are living through unprecedented times of Covid 19 Pandemic. The sudden onset and heavy impact of the Pandemic caught most of us unware and took us on a long roller coaster ride of uncertainty. We are in still the clutches of an unseen enemy that is dismantling us at our very genetic code level. However, we believe adversities bring out the worst & best in everything.

At the onset, we would like to pay homage to everyone who has lost near and dear ones during this Pandemic. We were among the more fortunate ones to not face such eventuality, but we all met our own dark places and have indeed learnt something positive. We will be sharing ten lessons and insights that we have learnt at various levels, including professional, community, administrative family, personal and global perspectives.

- **Use of the Internet**: Our use of online resources has exponentially increased during the Pandemic. The use of webinars, Zoom meetings, work from home, telemedicine all played a significant role during the last few months of our lives. And we predict these will continue to be part of our lives in future too. However, social media and online resources are also double-edged swords, and we have to learn to utilize social media wisely and optimally.

- **Work Expands to The Time Available:** Having more time was not the solution. With more available time, we realize that we were performing lesser. However, we now realize the importance of time more acutely than ever before, and we should incorporate good time management into our daily lives.

- **Administrative responsibilities:**
  As head of the hospital or organizations, we were in unique positions. We were faced with anxieties and fear of our staff and co-workers. We quickly realized reassurance & positive communication played a vital role. We also recognized the urgent need for the reorganization of our work systems and improved our working together. Challenging times help us differentiate between your faithful supporters. This realization helps us a lot in the long run.

- **Humility & Gratitude:**
  If we have to take one single lesson to take away from this Pandemic, then it will be humility and gratitude. Many people faced a tough times during the COVID pandemic and some of them have also lost running businesses and are struggling to make a come-back. This has made us to be thankful to the Lord and at the same time to be humble since we can never predict what will happen tomorrow. We now live life in a different view.

  We must stop complaining about minor things, be thankful that we are in a better position. We must keep showing gratitude to the higher power & have faith in whatever we individually perceive as Divine. It is one of our greatest sources of strength and courage.

- **Strengthen Family Relationships:**
  In our busy schedules, most of us had lost touch with our families, even with our close ones. Pandemic gave us time to strengthen these ties and reinvent them. We realized the importance of the safety of our family and understand that one of the greatest gifts that we have is that the closest people that we care for our.

- **Opportunity for Great Personal Development:**
  Pandemic also gave us enough time to introspect about ourselves and realign priorities in our lives. We needed to introspect & rediscover ourselves and our value systems. Many of us realized our long lost passions and started working on them, and hopefully, we would continue working on them.

- **Adequate reserves for bad times:**
  Money is essential, and those who had reserves and resources used them to tide over difficult times. We have to educate ourselves in terms of financial knowledge and be wiser about our economic outlooks and always save money for uncertainties.

  Everything was on a standstill but still life went on. Things like restaurants, malls, movie theaters, entertainment centers, air travels etc all were closed but life continued. We realized that many things that we thought were important in our lives were actually not and this realization will help us in future too.

- **E-education** is one of the greatest discovery of this Pandemic. The gain and sharing of knowledge were simplified, and it diversified into massive knowledge sharing platforms. Starting from schools to colleges to universities and national and international societies all focused on e-education. This increased the outreach of quality education to each and every corner of the world.

- **Pandemics shape history:**

Plague – 14th Century had 200 million deaths.
Smallpox – 15th Century – 50 million deaths.
Cholera – 1817 – 1 million deaths
Spanish flu – 1918 – 50 million deaths and now in Covid-19 ongoing – more than a million deaths so far and still counting. However, we realize that we are all in this together, and Together, we WILL Survive & Thrive. We have to realize that we are descendant's of cavemen, who braved and survived with much fewer resources, and we will survive this too. Humans by instinct are resilient and will surely bounce back on all fronts. Many of these lessons or insights we already knew; however, Pandemic has forced us to perceive these things intimately. We believe many of us have also learned more and different lessons from this Pandemic. We hope we all will come out of it as a better person, on all fronts.

Prof Parag Sancheti, Dr Ashok Shyam
Sancheti Insitute of Orthopaedics, Pune, India

Total Femoral Replacement in a case of Revision Total Hip Arthroplasty with Rare presentation of Multifocal Giant Cell Tumor – a case report

Dr Rajeev K Sharma

Introduction:

Giant Cell Tumor (GCT) of bone comprises 3-4% of all bone tumors.[1] It usually occurs in third and fourth decade of life. Most common sites are meta-epiphyseal regions of distal femur, proximal tibia and distal radius. It frequently breaches the cortex but intra-articular penetration is rare. GCT is a locally aggressive benign tumor but it may present as locally invasive and rarely metastatic.

GCT can be managed with simple procedures like extensive curettage and bone grafting.[2] Recurrence rate is very high which can vary from 18-50% as reported in different series.[3,4] In cases of recurrence and malignant GCT, en-block resection with tumor-free margins is the procedure of choice. To regain function and appropriate limb length, joint reconstruction with custom made tumor prosthesis is the only option available especially in large segment resection.[5] Total femur replacement is an important surgical option in limb salvage surgery in patients with oncologic reconstruction following major bone defects. However the mechanical complexity of total femur prosthesis design, poor soft tissue conditions lead to mixed outcomes which are reported in literature.

GCT usually presents with monocentric origin but it may also have multifocal or multi-centric origins. If it involves multiple sites in one bone, then it is known as multifocal. If it simultaneously involves more than one bone then it is known as multi-centric. We are reporting a rare case of multifocal multi-centric GCT in a young male involving whole of the femur with in-situ total hip prosthesis with implant loosening leading to pain and difficulty in walking.

Case report:

A 24 year old male from Uzbekistan, presented in April 2015 to us with pain in right hip and thigh for last 6 months. The pain was moderate to severe in intensity. The pain used to aggravate on walking affecting his activities of daily living. The patient was thin built. Local examination revealed diffuse globular enlargement of entire right thigh. On palpation swelling was tender and local temperature was raised.

In past history, patient had pain over right hip and thigh in the year 2010. That time he was diagnosed with GCT proximal femur right side for which resection of tumor and Total Hip Arthroplasty (THA) was done in his native country. Revision THA was done same side in 2011 for loosening of Implant by another surgeon in Russia. In 2014 patient also had history of painful lytic lesion on the other side (i.e. Left proximal femur) for which excision of proximal left femur and THA was done.

Radiography showed multiple expansile lesions involving whole femur with cortical ballooning and loosened prosthesis (Fig 1a, b, c & d). An open biopsy was done and it

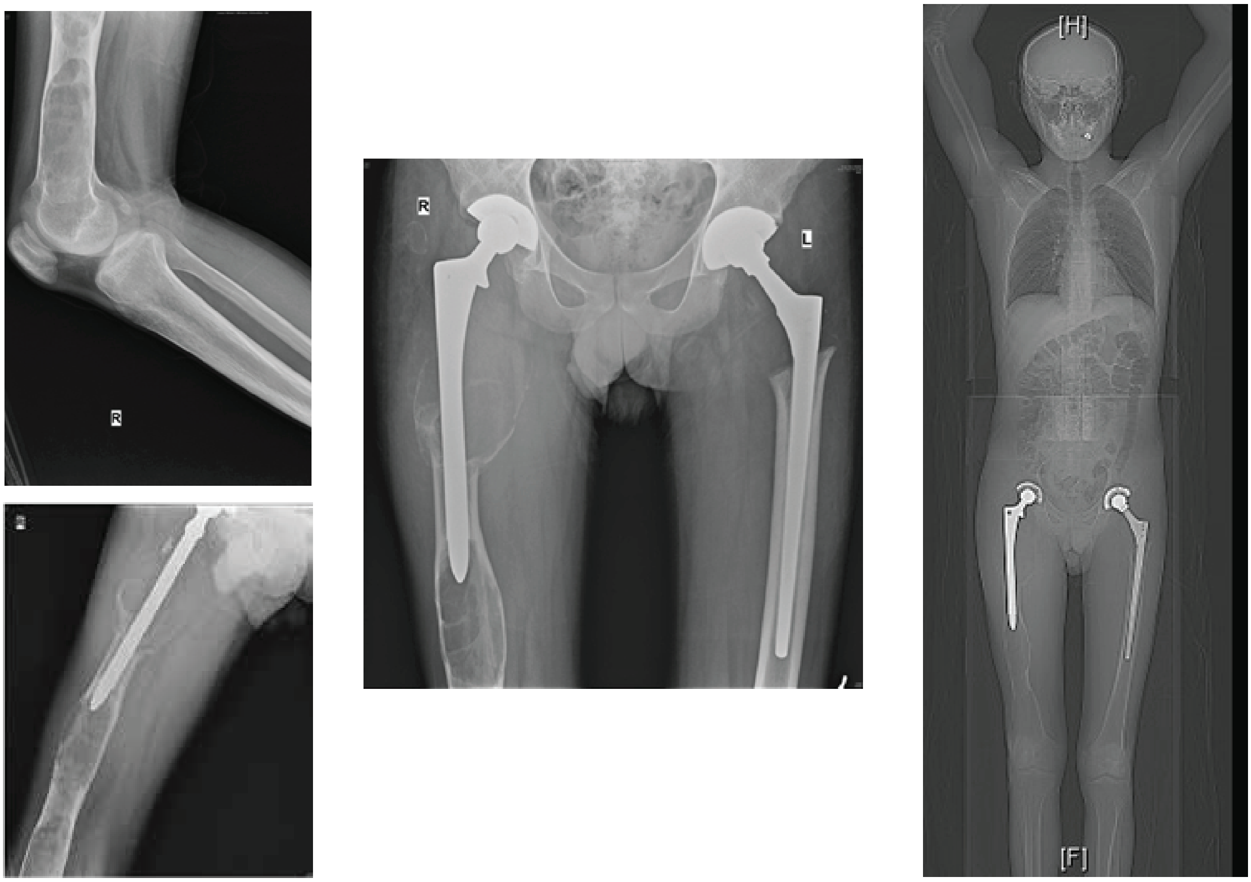

Fig 1 a, b, c & d: Multiple expansile lesions involving whole right femur with cortical ballooning and loosened prosthesis.

came out to be highly aggressive GCT (Fig 2). The only available treatment options were hip disarticulation or Limb Salvage by Total Femoral Replacement. Treatment options were discussed with the patient and attendants in detail and en-bloc resection of femur with Total Femoral Replacement was planned. Complete resection of the femur was done with preservation of the Neuro-vascular structures. Wide resection of tumor was done with tumor free margins (Fig 3a, b & c). Length of Femur was assessed and matched with trial and final implant. (Fig 4 a & b) Constrained Total Hip prosthesis with Total Femur and hinge rotating platform Total knee prosthesis was used (Johnson & Johnson, Depuy) (Fig 5 a, b & c).

Hip abductors and psoas tendon were sutured through the hole in the proximal part of the Total Femoral Prosthesis. Post-operatively active toe movement and isometric exercises were started on 1st Post-operative day. Limb was kept in abduction with the help of abduction brace. (Fig 6a, b, c & d). Partial weight bearing walking started on 5th post-op day with long leg brace. Full weight bearing started after 4 weeks. At 6 weeks active hip abduction was started. He recovered well and at the follow up of 6 years he is pain free, can perform activities of daily living with ease, can walk independent with mild abduction lurch and sit comfortably, having no signs of recurrence or loosening clinically or on x-rays. (Fig 7a, b, c & d)

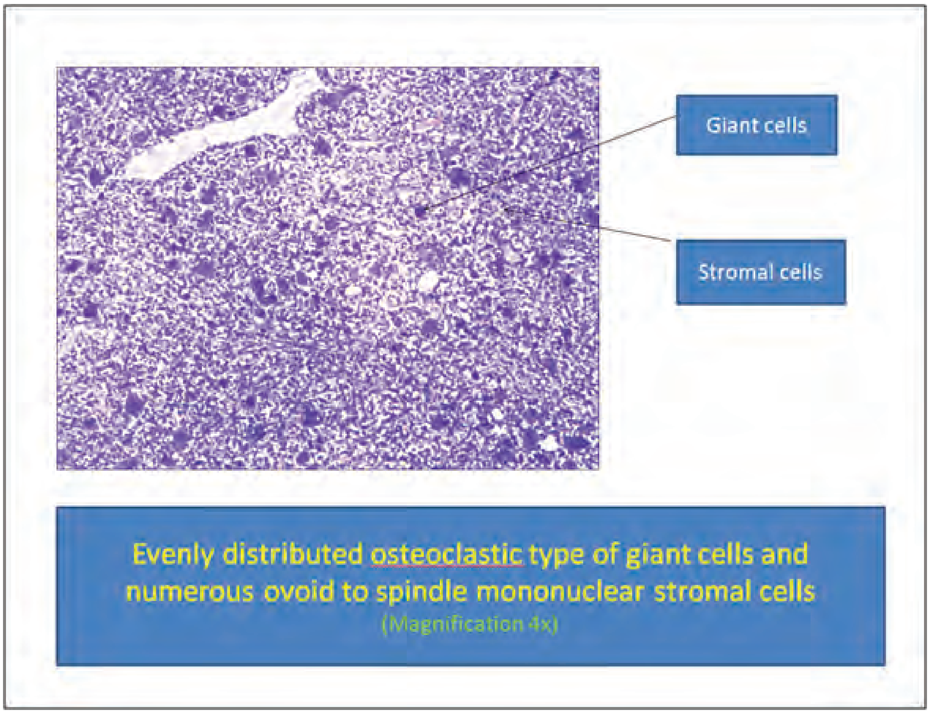

Fig 2: Highly aggressive GCT


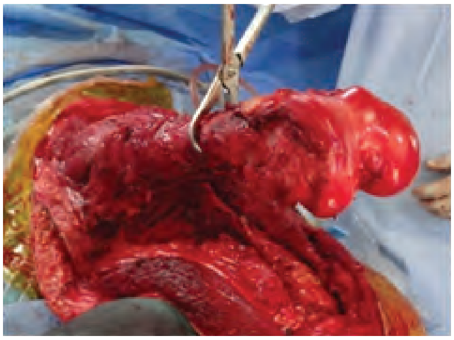


Fig 3a, b & c: Entire Femur was exposed and isolated, removed carefully avoiding damage to neurovascular structures.

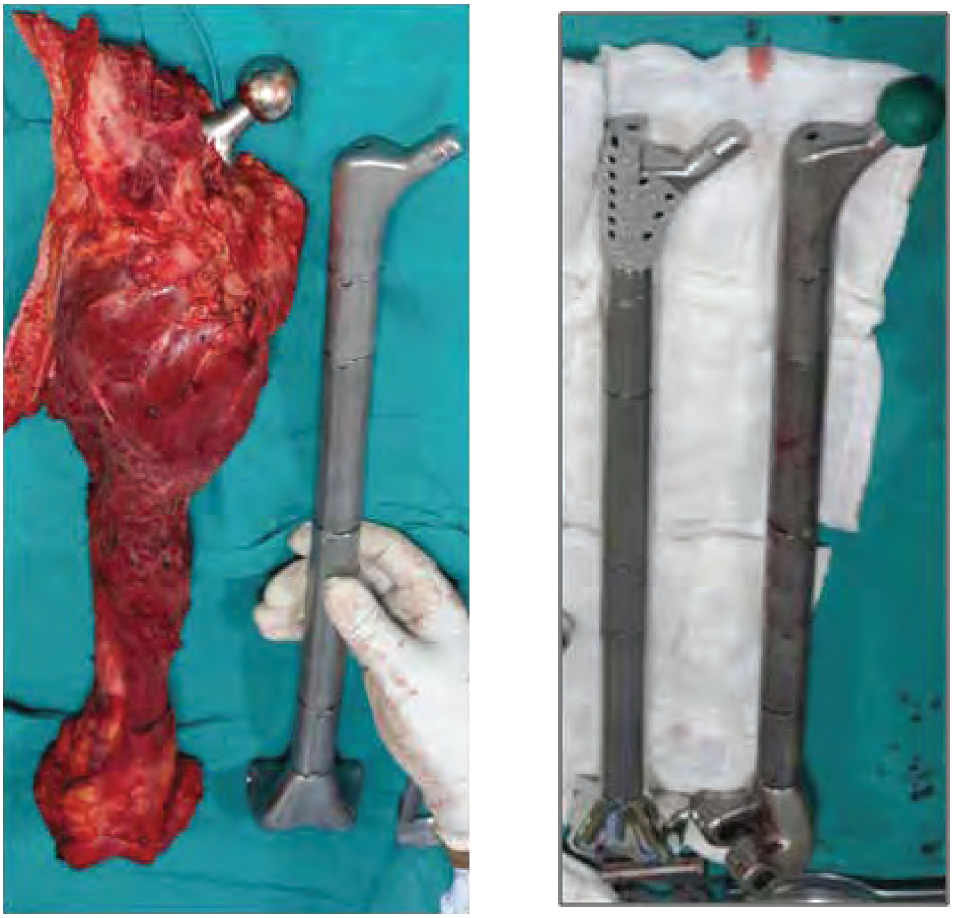

Fig 4 a & b: Length of Femur is assessed and matched with trial and final implant

Fig 5 a, b, c: Constrained Total Hip prosthesis with Total Femur and hinge rotating platform Total knee prosthesis was used (Johnson & Johnson, Depuy)

Fig 6 a, b, c & d: Constrained Total Hip prosthesis with Total Femur and hinge rotating platform Total knee prosthesis was used (Johnson & Johnson, Depuy)

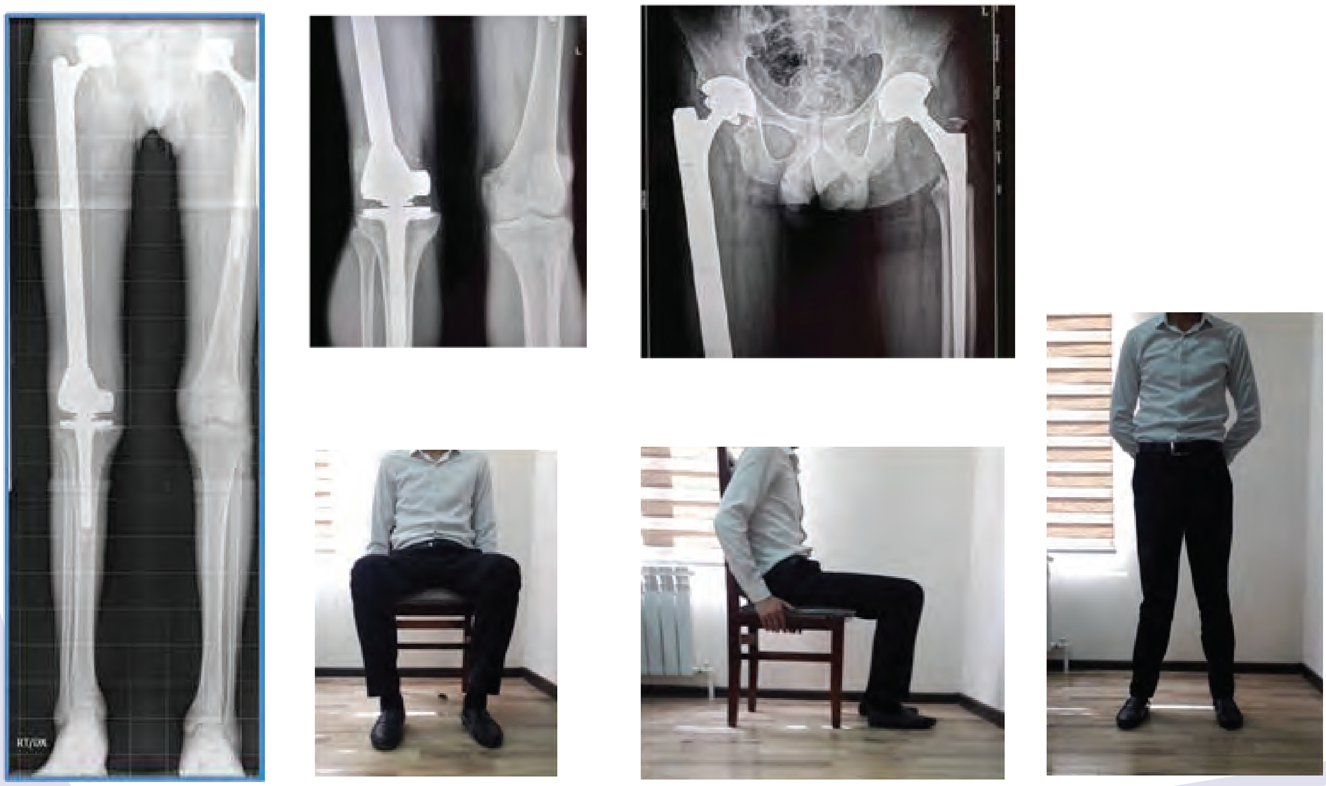

Fig 7 a, b, c, d, e & f: Six years Post Total Femoral Replacement with no recurrence or signs of loosening of prosthesis. Good functional outcome.

Discussion:

GCT is also known as Osteoclastoma and it produces osteolytic lesions in the meta-epiphyseal region of long bones. It more commonly occurs in young adults, especially in females. It is an eccentric, expansile lytic lesion without periosteal reaction. Patients present with pain, swelling, limitation of movement and very rarely pathological fracture. Histologically GCT shows characteristically brown, firm, friable solid mass with secondary hemorrhage. Microscopically it is composed of many multinucleated giant cell with 40-60 nuclei per cell and stromal cells which are mononuclear spindle cells. Treatment of GCT consists of intra-lesional extensive curettage with or without bone grafting. But all these measures failed to provide a definitive cure and results are ridden with high recurrence rates.[3,4] Recurrence can be treated by en-bloc resection of tumor with tumor free margins and limb salvage with custom-made tumor prosthesis. Sometimes femoral bone stock is so deficient that standard replacement prosthesis is not adequate, so for limb salvage, total femur replacement may become the only option. It requires extensive surgical exposure including neurovascular structure and appropriate implant positioning for adequate stability and functionality. Mankin HJ et al has done 15 Total Femoral Replacement in their series for different indications like osteosarcoma, chondrosarcoma, metastatic carcinoma, and an osteo-necrotic fractured femur in a patient with rheumatoid arthritis and for a patient with severe deformity based on Paget's disease, but not for multifocal GCT.[6]

Our patient had locally aggressive GCT involving full length of femur with prosthesis in-situ. Total Femur Replacement was the only option for limb salvage in this patient. Whole femur was removed en-bloc preserving medial and lateral collateral ligaments and quadriceps mechanism. Histopathology - the margins of resected femur were free of tumor cells. Constrained hip and hinge knee systems were used with total femur implant.

After Total Femoral Replacement, stability of the prosthesis is of prime concern. Dislocation of hip is most frequent complication, up to 14% following total femur replacement.[7-9] Kabukcuoglu et al reported 11% hip dislocation in their series and Bickels et al[10] reported only 1.6% hip dislocation in their series because of their meticulous repair of capsule and abductor mechanism. We have repaired hip joint capsule very meticulously. Hip abductors and psoas tendon were reattached to the holes of the neck of the prosthesis with heavy non-absorbable sutures. Constrained liner was used on the acetabular side. Since proximal tibia was not resected, the Quadriceps mechanism was intact with the tibial tuberosity. We re-attached the collaterals to the Prosthesis to gain some coro-nal stability around knee.

Takuya et al studied the clinical outcomes of patients with total femur prosthesis in patients with musculoskeletal tumor over the period of January 2003 to April 2014 in which they included patients with primary bone sarcoma and soft tissue sarcoma and they found the overall 3 year and 5 year survival rates of patients were 88.9% and 55.6%.

Also the overall survival rates in patients with primary bone tumors treated with total femur replacement were significantly better than those with primary soft tissue sarcoma.[11] M.D Sewell et al carried out retrospective review of 33 patients who underwent total femoral endo prosthetic replacement as limb salvage following excision of a malignant bone tumour. At five years the survival of the implants was 100%, with removal as the endpoint and 56% where the endpoint was another surgical intervention. At five years the patient survival was 32%.The mean Musculoskeletal Tumour Society functional outcome score was 67%, the mean Harris Hip Score was 70, and the mean Oxford Knee Score was 34 and hence concluded that total femoral endo prosthetic replacement can provide good functional outcome without compromising patient survival.[12]

Conclusion:

GCT is a locally aggressive tumor and can be managed by simple procedures like extensive curettage and bone grafting. Limb salvage procedures with appropriate prosthesis are necessary to provide adequate stability and functionality to the joint. Total Femoral Replacements are necessary in cases of extensive involvement of femur; otherwise the limb could not be salvaged after enbloc excision of femur. Total femoral replacement is an extensive and a technically challenging surgery but in such desperate situations in which the only other alternative is amputation, this procedure provides a painless, mobile and functional lower limb.

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References:

1. Natarajan MV, Prabhakar R, Mohamed SM, Shashidhar R. Management of juxta articular giant cell tumors around the knee by custom mega prosthetic arthroplasty. Indian J Orthop 2007;41:134-8.

2. Eckerd JJ, Grogan TJ. Giant cell tumor of bone. Clin Ortho Related Research 1986 Mar;(204):45-58.

3. Goldenberg RR, Campbell CJ, Bonfiglio M. Giant cell tumor of bone. An analysis of two hundred and eighteen cases. J Bone Joint Surg Am. 1970;52:619-64.

4. Trieb K, Bitzan P, Lang S, Dominkus M, Kotz R. Recurrence of curetted and bone-grafted giant-cell tumours with and without adjuvant phenol therapy. Eur J Surg Oncol. 2001;27:200-2.

5. Hillmann A, Hoffmann C, Gosheger G, Krakau H, Winkelmann W. Malignant tumor of the distal part of the femur or the proximal part of the tibia: Endoprosthetic replacement or rotation plasty. Functional outcome and quality-of-life measurements. J Bone Joint Surg Am 1999;81:462-8.

6. Mankin HJ1, Hornicek FJ, Harris M.Total femur replacement procedures in tumor treatment.Clin Ortho Related Research. 2005 Sep;438:60-4.

7. Ward WG, Dorey F, Eckardt JJ. Total femoral endoprosthetic reconstruction. Clin Orthopaedics. 1995;316:195–206.

8. Johnsson R, Carlsson A, Kisch K, Moritz U, Zetterstrom R, Persson BM. Function follow-ing mega total hip arthroplasty compared with total hip arthroplasty and healthy matched controls. Clin Orthopaedics. 1985;192:159–67.

9. Kabukcuoglu Y, Grimer RJ, Tillman RM, Carter SR. Endoprosthetic replacement for primary malignant tumors of the proximal femur. Clin Orthopaedics. 1999;358:8–14.

10. Bickels J, Malawer MM, Meller I, Kollender Y, Rubert KM, Henshaw RM. Proximal and total femur resections with endoprosthetic reconstruction. Surgical technique and pros-thetic survivorship: analysis of 64 patients. Presented at the 10th International Symposium of the International Society of Limb Salvage (ISOLS), Cairns, Australia, 11–14 April, 1999.

11. Kakimoto T, Matsumine A, Asanuma K, Matsubara T, Nakamura T, Sudo A. The clinical outcomes of total femur prosthesis in patients with musculoskeletal tumors. SICOT J. 2019; 5:23.

12. Sewell MD, Spiegelberg BG, Hanna SA, Aston WJ, Bartlett W, Blunn GW, David LA, Cannon SR, Briggs TW. Total femoral endo-prosthetic replacement following excision of bone tumours. J Bone Joint Surg. Br. 2009 Nov; 91(11):1513-20.

For the motion:

Robotic TKR is a "Hype"

A/Prof Nicolaas C. Budhiparama

Total knee arthroplasty (TKA) has been well established as an effective way to treat severe osteoarthritis. In the last 3 decades, new innovation has been the focus of the medical industry and surgeons to improve patient's outcome and satisfaction. New technologies in TKA are very attractive for surgeons and have constantly advanced. They allow surgeons to expand their knowledge of knee biomechanics, the possibilities and surgical indications as we strive to restore native knee functions. Nevertheless, all technologies should evolve through IDEAL (Idea, Development, Exploration, Assessment and Long-term follow up) stages.[1] Computer navigation (CAS) had been shown to decrease the proportion of patients with alignment more than 3° from neutral, but CAS was not associated with a corresponding improvement in validated functional outcomes scores. Based on this, one would ques-tion whether new innovations to achieving TKA alignment were worth the costs and the added surgical time. The majority consensus is that until these new technologies are associated with better survivorship or substantially improved outcomes scores in future studies, surgeons and hospitals should not use these approaches because they add both cost and risks for the patients and hospitals that are associated with the uncertainty of novel surgical approaches. Orthopedic surgeons should be cautious until evidence demonstrates an unbiased clinical superiority and cost-effectiveness. This process includes the long-term assessment of the advantages and limitations of evidence-based publications and critical appraisal of the author's disclosed conflict of interest to make sure that results are unbiased.

In the past 5 years, there have been many publications on Robotic-assisted TKA (RaTKA) compared to conventional TKA with mostly short to mid-term follow-up. Some papers showed the advantages of Robotics such as reduced bone and periarticular injury, accuracy in implant positioning and limb alignment, decreased total expenses, shorter length of hospital stay. The others showed no significant difference in functional outcomes despite an increased accuracy in implant placement and limb mechanical axis alignment. Unfortunately, although improved implant alignment might be associated with implant survivorship, it does not correlate to patient satisfaction.[2]

Parratte et al[3] had shown in their study that mechanical axis alignment may be the wrong target for TKA due to outliers over 3° have better survivorship at 15-year follow-up. This finding was later confirmed by Abdel et al[4] in their 20 years follow-up study. Hence, this is also why better limb alignment does not automatically translate into better functional outcomes nor patient's satisfaction.

Current Ra-TKA can assess ligament balancing by registering the pre-op laxity and compare it to the planning, the initial laxity assessment during the peri-operative stage still has to be done manually by a surgeon. The system will only register the amount of varus-valgus strength exerted by the surgeon. This assessment depends on the surgeon's strength while exerting a significant varus and valgus force on the knee, the patient's BMI, physical stature of the patient and anesthesia. The ligament balancing also depends on the surgeon's experience with the robotic system which remains challenging and subjective. On the other hand, technology such as PSI and ABN can determine the bone cut axis and implant positioning while remaining independent from ligament balancing.[5]

Ra-TKA also claims to reduce total expenses due to reduced analgesic consumption, decreased hospital LOS, readmission rates and greater home self-care discharges. Beyond the huge initial capital investment for the technology between 400K to 1.5 mil USD, some insurance companies do not approve Ra-TKA or the needed pre-op CT imaging as a medical necessity which leaves the uncovered expenses to the patient's financial responsibility. To avoid that, surgeons will need to create additional justification as a medical necessity or use different treatment planning codes in order to get insurance authorization. Mont et al[6] did a great job with the cost comparative study between Ra-TKA and Conventional TKA showing approximately 11% savings or about USD 2K when using Ra-TKA. Institutions considering to implementing RaTKA should also consider other potential and hidden costs such as maintenance fees, disposable cost, longer surgical time and preop imaging requirements specific to each platform. Therefore, for hospitals to remain economically feasible, these costs must be offset by high case volumes and better outcomes than the current technology used. A recent survey of American Association of Hip and Knee Surgeons members found that regardless of financial interest and use of the technology, felt that robot arm assistance increased operative time (76.5%) and was not more cost-effective than traditional methods (78.7%). Most AAHKS members felt that 20-40 surgical cases were needed to become competent with the technique (54.1%).[7]

Any new technology including Ra-TKA comes with a learning curve that varies depending on the machine user-friendliness and surgeon's experience with the surgical technique and technology. The learning curve will be different between an experienced surgeon and a fellow surgeon. The longer the curve, the more potential harm it carries for the patients. The learning curve also affects how often surgeons abort the robotic system during surgeries, switching back to conventional methods, currently ranging from 1 to 22% of the surgeries. The more familiar the surgeon and nurses are with the robotic system, the shorter the learning curve will be.

With the internet available globally, the public is receiving uncertain information about the latest technology. Since RaTKA is being used as a powerful marketing tool by surgeons or hospitals who are advertising the availability of RaTKA as being better than hospitals that do not. In a survey conducted by Pagani et al, participants prefer to have

RaTKA surgeries performed by low volume surgeons than conventional surgeries performed by high volume surgeons regardless if the results are comparable.[8] Public's unawareness of the dubious outcome superiority can led to misinformation and incorrect decision-making by patients. The three main concerns regarding Robotic technology included lack of surgeon experience with robotic surgery, robot malfunction causing harm and increased cost. Regardless of the findings, the public perception is still “The Latest is The Greatest” hence they prefer to be operated by robotic technology compared to conventional method.

With the various new technologies emerging in the past 3 decades ranging from computer-assisted surgeries (CAS), gender-specific implants, patient-specific instrumentations (PSI) to handheld accelerometer-based navigation (ABN) systems, we should learn our lessons from the trend of publications about them. For example, when CAS first emerged in the market, there were more than a hundred publications showing promising results and advantages. There were a few skeptical papers that showed no tangible benefits. As time progresses, with longer follow-up time, more and more papers claim the lack of expected benefits of CAS in terms of patient’s functional outcomes and satisfaction. Critical assessments of the papers come in handy when evaluating studies pertaining to new technology especially at an early or mid-term follow-up stage. As for ABN technology, we found that despite improved accuracy of positioning, not enough data had been published to support any functional benefit of ABN over conventional TKA.[9]

DeFrance et al[10] found that out of the 54 studies meeting their study inclusion criteria, 49 (91%) of them had at least one author with a financial conflict of interest, were industry-funded or published in less prestigious journals. Besides, nearly all studies (97%) of journals supporting Ra-TKA were published by authors receiving substantial financial compensation. From there, we gather that conflicted studies are more likely to report favorable results than non-conflicted studies. When we look at studies favoring conventional techniques, those demonstrating favorable robotics outcomes had a higher number of conflicted authors and a higher mean industry payment per author. More studies by authors without any conflict of interest may provide unbiased results. Unfortunately, an easily interpreted, randomized controlled trial is not the solution. It is not possible to randomize patients to a malalignment group.[11] Although 3° or even 5° may not matter, more-severe outliers may impact how a patient perceives his or her knee as well as implant survival.

In conclusion, although Robotic-Assisted TKA has shown short-term success, long-term success with improved survivorship and patient satisfaction with decreased rates of revision arthroplasty will continue to determine the value of robotic technology in TKA.

A/Prof. Nicolaas C. Budhiparama, *MD, PhD is Chairman, Nicolaas Institute of Constructive Orthopedic Research & Education Foundation for Arthroplasty & Sports Medicine, Indonesia - The Netherlands*

References

1. McCulloch P, Feinberg J, Philippou Y, Kolias A, Kehoe S, Lancaster G, Donovan J, Petrinic T, Agha R, Pennell C. Progress in Clinical Research and Surgery and IDEAL. Lancet. 2018 Jul 7;392(10141):88-94. doi: 10.1016/S0140-6736(18)30102-8

2. Singh V , Fiedler B , Simcox T , Aggarwal VK, Schwarzkopf R , Meftah M. .. Does the Use of Intraoperative Technology Yield Superior Patient Outcomes Following Total Knee Arthroplasty? J Arthroplasty 2020 Nov 6;S0883-5403(20)31161-X. doi: 10.1016/-j.arth.2020.11.001

3. Parratte S, Pagnano MW, Trousdale RT, Berry DJ. Effect of postoperative mechanical axis alignment on the fifteen-year survival of modern, cemented total knee replacements. J Bone Joint Surg Am. 2010 Sep 15;92(12):2143-9. doi: 10.2106/JBJS.I.01398.

4. Abdel MP, Ollivier M, Parratte S, Trousdale RT, Berry DJ, Pagnano MW. Effect of Post-operative Mechanical Axis Alignment on Survival and Functional Outcomes of Modern Total Knee Arthroplasties with Cement: A Concise Follow-up at 20 Years.J Bone Joint Surg Am. 2018 Mar 21;100(6):472-478. doi: 10.2106/JBJS.16.01587.

5. Batailler, C.; Swan, J.; Sappey Marinier, E.; Servien, E.; Lustig, S. New Technologies in Knee Arthroplasty: Current Concepts. J. Clin. Med. 2021, 10, 47. https://dx.-doi.org/10.3390/jcm10010047.

6. Mont MA, Cool C, Gregory D, Coppolecchia A, Sodhi N, Jacofsky DJ: Health care utili-zation and payer cost analysis of robotic arm assisted total knee arthroplasty at 30, 60, and 90 days. J Knee Surg 2019; September 2 [Epub ahead of print]. doi: 10.1055/s-0039-16957415.

7. Sherman WF, Wu VJ. Robotic Surgery in Total Joint Arthroplasty: A Survey of the AAHKS Membership to Understand the Utilization, Motivations, and Perceptions of Total Joint Surgeons. J Arthroplasty 2020 Dec;35(12):3474-3481.e2. doi: 10.1016/j.arth.2020.06.072

8. Pagani NR, Moverman MA, Puzzitiello RN, Menendez ME, Barnes CL, Kavolus JJ. Online Crowdsourcing to Explore Public Perceptions of Robotic-Assisted Orthopedic Surgery. J Arthroplasty. Published online Februay 15, 2021

9. Budhiparama NC, Lumban-Gaol I, Ifran NN, Parratte S, Nelissen R.Does Accelerometer-based Navigation Have Any Clinical Benefit Compared with Conventional TKA? A Systematic Review Clin OrthopRelat Res. 2019 Sep;477(9):2017-2029. 10.1097/CORR.0000000000000660.

10. DeFrance MJ, Yayac MF, Courtney PM, Squire MW. The Impact of Author Financial Conflicts on Robotic-Assisted Joint Arthroplasty Research. J Arthroplasty. 2020 Oct 26:S0883-5403(20)31131-1. doi: 10.1016/j.arth.2020.10.033.

11. Landy DC. CORR Insights®: Are There Differences in Accuracy or Outcomes Scores Among Navigated, Robotic, Patient-specific Instruments or Standard Cutting Guides in TKA? A Network Meta-analysis Clin Orthop Relat Res. 2020 Sep;478(9):2117-2119. doi: 10.1097/CORR.0000000000001399.

Debate : "Robotic TKR is a Hype"

Against the motion :

Robotic TKR is “One small step for man…,”

A/Prof Rami Sorial *Dr Vaibhav Bagaria* *Dr Rohit Pandey*

During the 1960 US presidential election one JFK stated that “We stand today on the edge of a “New Frontier” the frontier of the 1960s, the frontier of unknown opportunities and perils, the frontier of unfilled hopes and unfilled threats. Beyond that frontier are uncharted areas of science and space”. Well fast forward to 2021 and here we are dealing with unknown perils in the form of Covid 19 pandemic with yet unknown outcomes more than a year into that threat to mankind, but we are also enjoying unknown opportunities brought to us by the advances in artificial intelligence.

Robotics is certainly a central figure in that space and as orthopedic surgeons we must remain both vigilant but relevant in engaging with these opportunities. It is not sufficient to sit back and say let us see the evidence when you have it, but we need to be engaged and leaders in this space to ensure that we can harness the full power and capacity of what modern science has to offer to improve outcomes for all our patients.

DynaTac 8000X is the name of the very first commercially available handheld mobile phone introduced in 1984. It had a 30-minute talk time capacity and could store 30 phone numbers and cost $3995. Now for a fraction of that price we have the Samsung S21 Ultra and the iPhone 12 with near limitless capacity. So, to the current generation of robots for joint arthroplasty, we as clinicians have access to a variety of active and semi active robots many of which are still in their first or second generation of evolution. The paper that follows is an in-depth analysis of the different robotic platforms and a discussion of the evidence base around these at present. I have personal clinical experience with one of these platforms and will share that experience to date as an introduction to the balanced review of what surgeons should consider state of the art technology for our craft. How this evolves over the next decade will be exciting to observe and if it follows the development of similar well supported and funded commercial devices then one can anticipate a smart tool that will allow us to deliver accurate and reproducible surgery to every patient regardless of deformity.

Market research predictions for the global growth of orthopedic surgical robots is a 13% compound annual growth rate between 2019 and 2029 reaching $4.1 Billion. It is forecast that hip and knee replacement robotics will grow from $84 million in 2015 to $4.6 billion in 2022. The industry has invested heavily in this space and it is imperative on us as clinicians to ensure that what applications are developed are to only benefit our patients driving longevity of implant survivorship, improving patient satisfaction and decreasing the volume of revision surgery in the future.

My practice over the last decade has incorporated PSI as a routine instrument for TKA and this technology has many benefits in my hands including simplification of the intra-operative procedure, once pre-operative planning is completed, reduced need for prosthesis inventory as implant sizes are very predictable from each individual plan and with good outcomes delivered secondary to improved accuracy of implant positioning (https://-doi.org/10.1111/ans.12674). We collectively recognise that 10% to 15% of our TKA patients are not completely satisfied with their outcomes and it is this group that current and forward technologies will focus on to improve patient satisfaction. Whilst PSI set out to provide improved alignment of implants, it did not allow intra operative validation of any of the cuts and provided no validated intraoperative assessment of the soft tissue envelope that is critical in the subsequent pain free range of motion that each patient will aim to achieve. This may explain why in our review of 444 TKA patients using PSI we could not correlate that better alignment resulted in better outcomes (https://-doi-org.ezproxy.library.sydney.edu.au/10.1016/-j.knee.2019.08.004). Robotic guided arthroplasty offers intraoperative validation of each cut and each implant positioning and considers the soft tissue component in the algorithm for determining prosthesis position and size. The ability to tweak and altar final position and size especially that of the femoral component to accommodate the soft tissue envelope after confirming the cut plane on which each prosthesis will be based really improves flexion balance and range of motion. This is then represented in a digital format that can remain as a printed document in the patients record. This data collected across many patient interactions has the potential to allow learning and ultimately may allow us to introduce an algorithm in the future that can assist in optimising patient outcomes for all grades of deformity.

My personal experience with ROSA over the last year with over 130 patients to date has been positive with a small learning curve made easier by the routine use of technology in my practice planning for PSI prior to use of the robot. The introductory course and cadaver labs were also valuable prior to commencing use of the robot in clinical cases. Use of the robot has changed my approach to TKA substantially with confidence that I am delivering the intent of each step and validating with the opportunity to correct further where needed. Previously utilising a strictly mechanical alignment, measured resection technique reproducing the trans-epicondylar axis for femoral rotation in every case, the exposure would routinely involve an extensive medial to posteromedial release in varus deformity and anterior subluxation of the tibia on the femur prior to the tibial cut.

My current surgical approach with the robotic technique even in significant varus and valgus deformity no longer employs any significant soft tissue releases during the exposure and may only incorporate some releases at end of very few cases to tweak and improve balancing the gaps. I no longer translate the tibia anteriorly and cut the tibial osteotomy with the knee reduced. Utilising a flexion gap tensioning device (FuZion device) with confidence that the tibial cut is accurate and validated has allowed the femoral rotation to be predicated by the soft tissues and no longer use the TEA for alignment improving flexion gap balance and virtually eliminating the need for further soft tissue releases. The robotic algorithm also allows the visual use of cues to upsize or downsize the femoral component plus or minus AP translation to see immediate effect on balance before committing to that action.

Primary assessment

Tibial cuts validated

Flexion balance with tensioner

Final balance with implants

The use of the robot has added up to 10 minutes extra to the surgery with insertion of the femoral and tibial arrays and registration landmarking. To date no specific complications have been seen with our patients from use of the robot.

Although anecdotal at present my observations are that patients are far more comfortable in the first 48 hours post op and achieve their range to 90 degrees faster, but this needs to be documented more scientifically. We have collected implant positioning data using the CT Perth Protocol on post op patients at 6 weeks and the most notable findings when comparing my last 67 patients using PSI to my first 80 patients using ROSA is the sagittal alignment of both the femoral and tibial components is improved with the robotic assist technique:

Femoral component flexion (3 degrees +/- 3 degrees) – PSI 54% vs ROSA 81%

Tibial component slope (7 degrees +/- 3 degrees) – PSI 82% vs ROSA 91%

Mechanical Alignment (0 +/- 3 degrees) – PSI 73% vs ROSA 84%

Notably the coronal implant positioning is similar for both PSI and ROSA at around 94% and 96% for the femoral component and 89% and 87% for the tibial component.

Publications to date demonstrating functional outcomes and early functional recovery are detailed in the discussion paper below. More data and randomised trials are required to establish superiority as we have not mentioned costs, and this is a significant variable that is different for the different platforms and will vary depending on the financial set up of the institution involved in the purchase. Costs may vary from no added cost to as high as $900,000 per unit depending on the circumstances. Functional costs will also vary based on the volume of work at the specific institutions.

Whilst I am personally very positive about the potential benefits of robotic assisted surgery for TKA and may appear to be an early adopter with little evidence base to reflect on, I would suggest that this is simply another instrument that the majority of surgeons will adopt in time to perform TKAs more effectively. My good friend and colleague Prof. Nico will always argue that the "latest is not always the best", the retort would be that if we did not progress cautiously because of fear of uptake of new technology then we would still be cutting the tibia like my senior mentor when I was a junior registrar using a plumb bob and a ruler.

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In depth analysis of different robotic platforms –

Arthroplasty is a reliable treatment for osteoarthritis. There has been a surge in the number of arthroplasties done all over the globe, according to the Australian national joint replacement registry there has been 643,567 hip and 782,600 knee joint replacement in 2019 (1). Since the advent of arthroplasty, there has been various modifications in terms of material used, surgical technique and use of technology such as patient specific instrumentation, navigation and now robotics. Over the years, it has been accepted that good soft tissue balancing, appropriate implant choice and alignment within 3 degrees of mechanical axis leads to better longevity of implant and patient satisfaction (2,3,4). Robotics has the potential of providing a means to do these procedures with greater precision and reproducibility.

Although it is quite early to predict the actual impact of robotics in arthroplasty, early results are promising in terms of alignment and subjective outcome measures, and multiple recent meta-analysis support the same for TKA and UKA (5,6).

Robotic assisted knee arthroplasty appears to be the best foot forward, as it takes away the volatility of the human operator and gives a lot of data both pre-operatively, intra and post operatively, which can be assessed to move forward towards a more customized arthroplasty and decrease the ratio of unsatisfied to satisfied patients, currently 20:80 (7,8,9,10). With a properly done knee replacement, currently patients report the outcome of a "forgotten knee" in around 42.9% of TKRs (11). Over the last decade there has been ample interest in robotic surgery and different com-panies are investing heavily in this technology. Now there are multiple robots available and its quite difficult to differentiate which one is better. MAKO, ROSA, OMNIBOT, ROBODOC, NAVIO are some of the current front runners in this field of robotic technology and they provide a spectrum of information and techniques in arthroplasty.

Our aim here is to discuss and share some of the different robotic platforms currently available describing the basic technology used by each and pointing out the perceived advantages and disadvantages.

Table 1: Currently Available Robotic Platforms

1. **ROSA (Zimmer Inc)**
2. **Navio/CORI (Smith -Nephew Inc)**
3. **MAKO (Stryker Inc)**
4. **OMINBOT (CORIN)**
5. **ROBODOC/Cuvis (Curexo Inc)**
6. **VELYS (DePuy Synthes) NB:** at time of this article this is not globally launched

ROSA

Make: Zimmer Biomet, bought ROSA technology in 2016 from French company Medtech and launched it in 2019 with only TKA option at present.

Semi active – It provides a robotic arm (fig 1), which accurately places the cutting guide at the precise location, within the stereotactic boundaries. Surgeon has freedom to manually use saw to make the bony cuts with no haptic boundaries. It allows distal femur and proximal tibia cuts and accurately places 4 in 1 block in rotation according to the inputs provided in planning phase. It also assesses flexion and extension balance as part of the process in determining implant size and positioning.

Image and image free: The System gives options for both image and image free technique. Image free option does not provide tibial baseplate size. Image based system, requires either pre-operative X ray or MRI following a particular protocol. It provides pre-determined plans based on surgeon selected defaults or criteria and can be adjusted intraoperatively after anatomical landmark registration and soft tissue balance assessment. A "Fuzion" device allows femoral rotation to be adjusted to balance the flexion gap, adopting an optional gap balancing technique.

Device description: It has two units, one positioned on each side of the operating table:

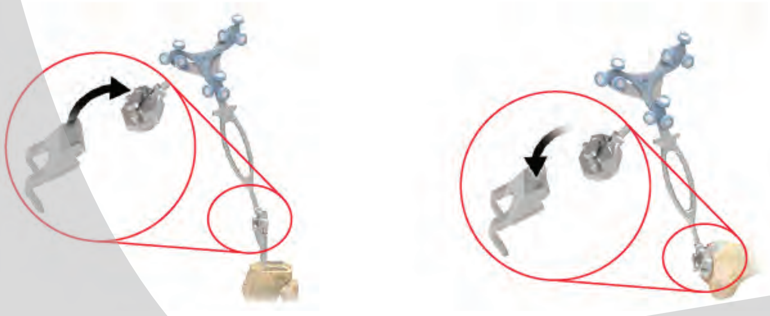
- A robotic unit consisting of a compact robotic arm and a touchscreen
- An optical unit and a touchscreen

Robotic arm has a force sensor showing whether anything is attached on arm and can be moved manually by surgeon into the final landing position for patient safety.
There are two touch screens– one on robotic arm and the other on the optical sensor.
Vigilance device (foot pedal) – moves robotic arm into position only when the pedal is pressed.
Optical unit consists of

- The optical camera – laser class 2 (power inferior to 1 mW, eye protection by the palpebral reflex) integrated into it.
- The camera positioning arm
- The touch screen

Compatible implants: It is a closed system, allowing only fixed bearing implants. NexGen®CR, NexGen CR-Flex, NexGen CR-Flex Gender, NexGen LPS, NexGen LPS-Flex, NexGen LPS-Flex Gender, Persona® CR, Persona PS, Vanguard® CR, and Vanguard PS.

Setup requirements:
It has 3 reference points one each array on femur, tibia and robotic arm.
Position of robot is at hip level 45 degree relative to surgery table.
Validation of cut: Reference tool with two parts 1- body, 2-distal and posterior condyle extension
For tibial cut validation need both part and for femoral distal cut only body part is required (fig 2).



At the start, robot registration moves through 6 positions. Mapping of femoral head requires 14 static points. Deepest point is selected on tibia and femur to define bony landmarks as it is based on X ray, however there is no need to pierce intact cartilage.

References required on femur are femoral head, anterior and posterior trochlear groove, femoral canal entry point, posterior condyles, medial and lateral distal condyle, anterior cortex, medial and lateral epicondyles. On tibia, medial and lateral malleolus, tibial entry point, PCL insertion, medial and lateral plateau surfaces.

User interface

Preferences are classified into the following categories:

- Femoral Rotation Axis Display
- Posterior Condylar Axis (PCA) – always shown on screen
- Transepicondylar Axis (TEA)
- Anterior Posterior Axis (AP)
- Knee State Evaluation – have to activate otherwise not shown operative leg's range of motion (in degrees) with alignment of the leg, as well as varus/valgus deformity (in degrees) at different angles and ligament laxity (mm; in flexion and extension) when the surgeon proceeds with a stress test of the operative leg. Can do it initial, intraoperative and final.
- Femoral Rotation Tool – also have to activate, used to assess intra operative laxity with pull test or lamina spreader and relation with femoral rotation.
- Flexion Angles for Stress Tests - 30, 45, 60 and 120 degrees of flexion indicators in the EVALUATION panel in addition to the 0 and 90 degrees required values. By default, the 0 and 90 degrees cannot be unselected and will always be displayed.

Workflow

- Initially pins for trackers are inserted on femur and tibia, then tracker instrument attached on robotic arm. Bony landmarks are identified with probe, then post condylar axis is identified with specific instrument.
- At onset robotic arm moves in automatic mode in desired cut plane and then in collaborative mode it can be adjusted in defined plane. Robot can readjust according to the movement of leg.
- Initially move leg without varus and valgus stress in ROM and then with stress to assess medial and lateral gaps.
- Then on the screen one can see the plan of measured resection, showing gaps and bony cut with implant, without any releases yet.
- Once done, one can proceed with distal femur or proximal tibia first option. After the cut validation tool is used to measure accuracy of the cut. Then assess extension gap with spacer block and flexion gap can be assessed manually too. Robotic arm is brought again to position pin hole for 4 in 1 block.
- Once gap assessment is done, either pre plan on measured resection can be used or if option of femoral rotation (balancing) is selected, then either lamina spreader or Zimmer Fuzion is used to measure extension gap and recreate it in around 90 degrees of flexion. Balancing can be done by bony cuts, femoral rotation and implant size and positioning. Screen shows knee from 360-degree view to assess all implant parameters. Implant positioning gives both anterior and posterior referencing options. Real time assessment can be done preoperatively, intra operatively and after implantation.

MAKO

Make: Stryker, acquired it in 2013, then launched hip arthroplasty in 2015 and knee arthroplasty in 2017. Gives option of all three THR, TKA and UKA.

Semi active – Mako is a robotic arm with saw/ burr options (Fig 3), it provides stereotactic haptic boundaries for all femur and tibia cuts. It also provides real time assessment of amount of bone removed and depth of bone remaining to be removed. Also, if some part is not accessible within the boundary, stereotactic mode can be deactivated.

Image based – This is a CT based system, which correlates CT landmarks with intra operative bony landmarks. CT slices are required at least 20 mm above the superior femoral component flange tip to prevent notching. It has slicer view to assess overhang of components accurately.

Device description: It consists of following components:

- Robotic Arm
- Camera Stand
- Mako Knee Instrumentation
- Mako Knee Array/Balancing Kit
- Mako Power System and Attachment Kit (Cutting System)
- Leg Positioner Kit

Leg positioner is important part of setup, which is not required in ROSA. It has sharp and blunt probes to exactly assess landmarks with or without cartilage thickness.

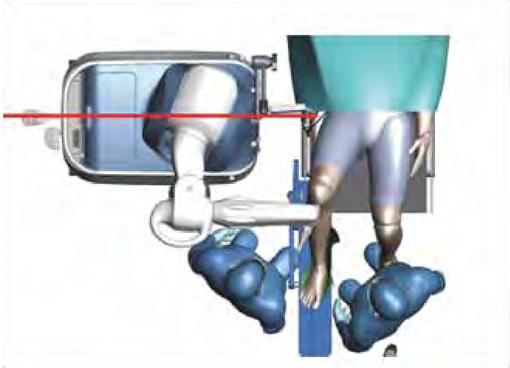
Implant compatible: Closed system: Triathlon Total Knee System (CR/CS/PS Cemented Primary), KINETIS Total Knee System (CR/UC).

Setup requirements

Bone Registration requires three steps: Patient Landmarks, Bone Checkpoints, and Bone Registration and Verification.

Limited patient landmarks are required such as hip center, medial and lateral malleoli and knee center. Patient landmarks are validated intra operatively with CT scan. Then bony checkpoints are required at least 10 mm from bony cuts, it provides extra fail-safe mechanism. Bone registration process is in depth and relatively more cumbersome as 40 points (10 groups of 4 points each) are required on both femur and tibia. Penetration of cartilage is paramount to get these points as it is CT based.

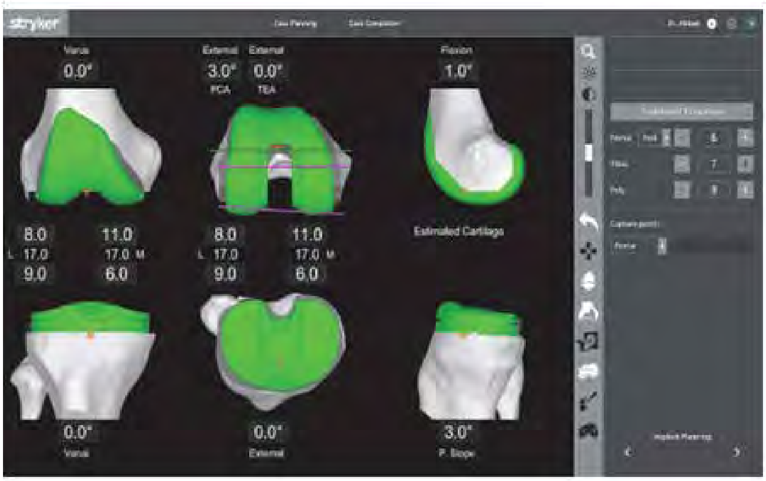
Center of the Robotic Arm base must be at the patient's hip, perpendicular to the surgical table, and about 3-5 feet from the surgical table. Mako Centerline (refer to red line in adjacent image) is perpendicular to the table rail. The front of the Mako is parallel with the table rail and the MICS handle is at knee center. There should be a fist width of space between the bottom of the MICS handle and the knee joint and then lower the Robotic Arm onto its feet (fig 5).



User Interface

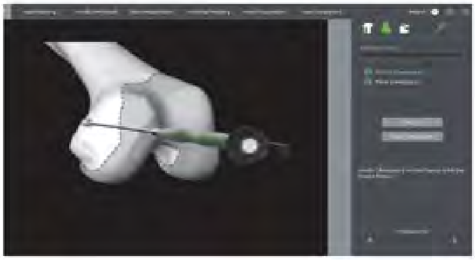
It provides following preferences to the surgeon:

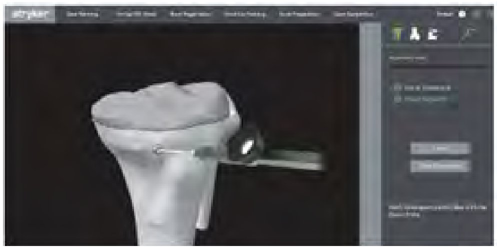
- Measured Resection or Ligament Balancing workflow – as per discretion of the surgeon
- Distal/Tibia Cut First (this option also available in ROSA) or Pre-Resection Balancing. If Ligament Balancing workflow is selected, 'Distal/Tibia Cut First' enables bone resection to set the extension gap before balancing the flexion gap, whereas Pre-Resection Balancing allows the surgeon to balance gaps before any bone resections are made.
- Perform RIO Setup and RIO Registration before Bone Preparation. Selecting this preference moves these steps from their default position of after Probe Check to before Bone Preparation.
- Bone Resection or Estimated Cartilage. This takes into consideration that cartilage thickness is 2mm everywhere, hence provides both values with or without cartilage.
- Display Total Combined Resection Depth in both compartment in flexion and extension (Fig 4).
- TKA Cutting Sequence. Sets the order of the cutting steps for the femur and tibia. In ROSA only option is to choose between distal femur or proximal tibia.



Workflow

- Through the standard approach, which is preferred by the surgeon, trackers (VIZADISC) are installed on both femur and tibia.
- Then registration process in undertaken, hip is taken into circumduction to identify femoral head, knee center is identified by most distal point in trochlear groove, tibial medial and lateral malleoli are identified and ankle center is calculated.
- Femoral and tibial checkpoint is installed on the bone (Fig 6), and then around 40 points are collected on both femur and tibia in set of four (Fig 7).
- Use pointed probe for this as one needs to pierce the cartilage and to validate cuts blunt probe is used.
- Once points are collected screen shows accuracy of collected points with reference to CT image and if there is discrepancy then again, those points are recollected.
- Leg is taken in complete range of motion initially without any stress and then with varus and valgus stress, software gives information of current status of knee, its deformity and range of motion (Fig 8).
- Then on the basis of CT there is one operative plan, which can be overwritten after doing range of motion with stress.
- When the robot is within 100 mm or less of patient's knee, it is activated and a yellow stereotactic boundary is indicated, this is approach mode and when this boundary changes to green it becomes cutting mode.
- There is option of two workflows as per surgeon's preference, measured resection or ligament balancing.
- In measured resection it shows medial and lateral spaces and gives options to modify them on the basis of joint balancing and implant positioning.
- Similar to ROSA, but ROSA gives information separately of space and bony cuts. Ligament balancing option utilizes knee tensioner or lamina spreader and recreates tension obtained in extension into flexion and getting femoral rotation accordingly.
- Also, as in any ligament balancing it is important to remove all osteophytes before going to flexion space.
- The Knee Tensioner (Fig 9) can expand up to 22 mm. For expansions greater than 20 mm, a 5 mm spacer shim is required. Use of the Knee Tensioner at distractions greater than 25 mm is not recommended due to the inability of the Knee Tensioner to transfer load to the joint at its upper limit.
- Once plan is selected real time assessment of saw can be seen on the screen and amount of bone removed is also displayed (Fig 10). It thereby prevents damage to the popliteal artery and PCL.





OMNIBOT

Make: CORIN, purchased from OMNI in 2018, it mainly focusses on total knee replacement

Semi Active: This is a semi active robot, which in addition gives option of using a balancing tool to assess gap on the basis of ligament tension in Newtons, which is unique to this robot. It mainly acts as a precise cutting guide with stereotactic boundaries and other feature is that it has robot anchored to the femoral bone itself, it is not a full robotic arm (Fig 11). This only allows executing the femoral cuts whilst the tibial cutting block is secured with free-hand navigation.

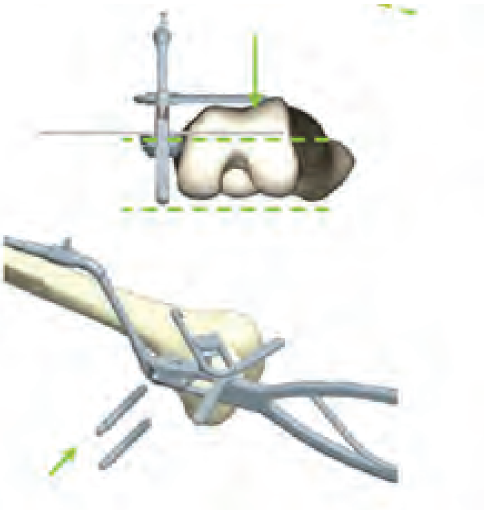
Image free: This bot uses the technology of bone mapping, so pre-operative imaging is not required. It creates 3D bone model of the knee.

Device description

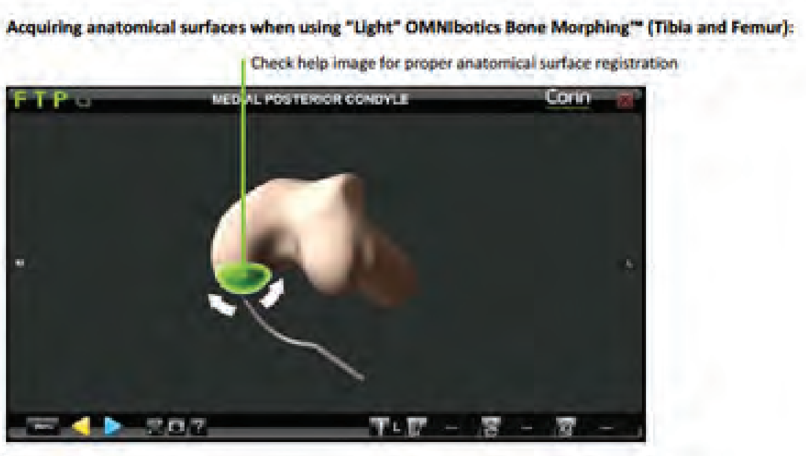
- It consists of an accurate cutting guide, within 1mm and 1 degree, for all femoral cuts, which changes position after every femoral cut (Fig 12).
- Balance bot – to measure ligament tension in both the compartments throughout range of motion.
- Camera with screen

Setup requirements

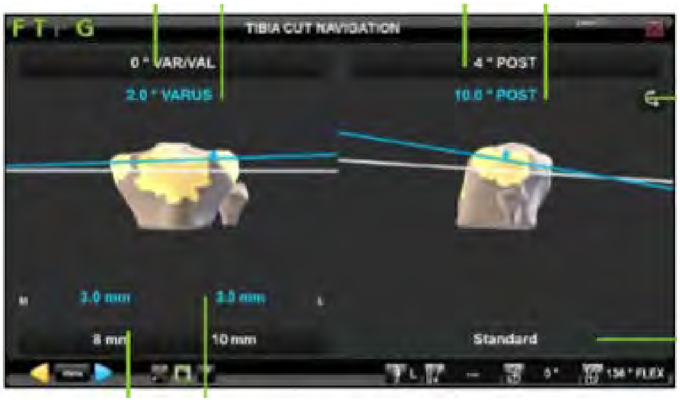
It requires 4 markers one each on femur, tibia, pointer and guide. This gives color code to the screen with green as visible and red meaning not visible. There is option of 3 or 4 marker array, while operating and total of 20 markers are required in each case. Camera must be on opposite side of surgeon and at around 6 foot distance. The “Femur Bone Fixation Base” clamps onto the “Cancellous Bone Screws” with a permanently captured 3.5mm hex locking screw. While determining the position of the bot, the guide must touch the medial distal condyle and stylus must touch anterior femoral cortex (Fig 13). Accurate position is 5 mm anterior to insertion of MCL on femur. Patient landmarks 15 cm diameter circumduction is required to detect hip center, then medial and lateral malleolus is identified, followed by knee center, anterior tibial tuberosity.



Bone morphing - have to collect around 500 points and paint whole of condyle to morph femur (Fig 14). Then validation of the bone morphed is done with pointer and it must be within 1mm. Tibia is morphed with single point registration or light bone morphing. Default cut is 9mm distal femur, 11 mm post condyle and 3-degree external rotation.



For tibial cut freehand navigation of cutting block and its orientation to planned tibial cut. (Fig 15). It has option of blade guide and nano block (it shows screws which when properly aligned to the cut displays green signal).



Implant compatible – it is a closed system using APEX knee system with both PS and CR option. Modular tibial implant can also be used, which is unique to it.

User interface

There are two options:

- Measured resection – femur first
- Ligament balancing – tibia first

Force control and height control mode in balance bot – maximum force up to 200 N.

Workflow

Knee is approached as per surgeon preference, then arrays are installed on the femur and tibia. This is followed by landmark acquisition and bone morphing of the femur. On tibial side single point registration is done. As bone is morphed it can be validated with a probe, if it is within 1mm, surgeon can proceed further.

Knee is first taken without any stress through range of motion, followed by varus/ valgus stress induced and real time values are displayed on the screen.

The option of measured resection is displayed on the screen, gap size can be modified with implant re-positioning or further bone resection. If surgeon chooses ligament balancing option, use of balance bot is required. In balance bot option the tibia is always cut first, then force is measured in both compartments and then it is balanced in flexion.

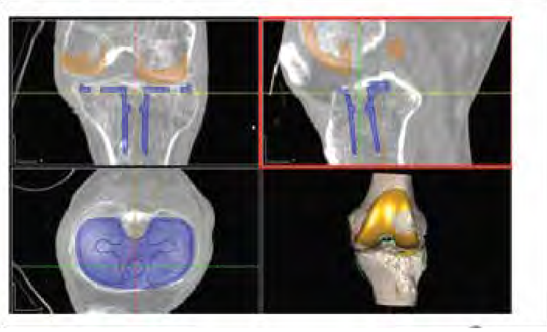
Surgeon has to install bot on femoral side, then initially bot has to be in the posterior most position, from where it does initial orientation process. Then femoral cuts proceed in following order distal, anterior, posterior, anterior chamfer and posterior chamfer.

ROBODOC

Make: Curexo Technology, Fremont, CA, this is first robotic platform used for TKR in 1992. Then Curexo changed its name to THINK Surgical Inc. (Fremont, CA) in September 2014, renaming Robodoc as TSolution-One. It gives option of THA, TKR and revision surgery to remove cement.

Active: it is one of its kind, it is an autonomous system, which works on the principle of milling. Initial planning is done by the surgeon, but rest of the procedure is undertaken by the robot, with surgeon having the option to override it, if he feels any deviation is required from predetermined plan. As compared to its counterparts, it doesn't give option in between cuts to remodify, once plan is made, then both femur and tibia milling is done, after which implant position and balancing can be assessed.

Image based: This system uses pre-operative X ray or CT scan of 3mm slice to pre plan the surgery. TPLAN3D planning workstation (THINK Surgical, Inc., Fre-mont, CA) for image-based preoperative planning (Fig 16).



Device description

- ORTHODOC®, a three-dimensional (3-D) workstation for preoperative surgical planning
- ROBODOC® Surgical Assistant, a computer-controlled surgical robot utilized for precise bone cavity and joint surface preparation for total hip arthroplasty (THA) and total knee arthroplasty (TKA) surgeries.
- De Mayo Knee Positioner

Implant compatibility: It is a unique "open system" having both PS and CR options.

Setup requirement

A total of 42 points is required for bony registration. Two 5 mm Shanz pins are required, one in lateral femur and the other in lateral tibia.
Bone Motion Monitor: Two BMMs (one on the femur and one on the tibia) are used for TKA. If bone motion is sensed, the new location of the bone(s) is determined by locating recovery markers.
ROBODOC has an accuracy of less than 0.4 mm.
Intra operative registration is done on the basis of pre-operative 3D plan.
Femoral rotation is measured on the basis of TEA and Tibial rotation on medial 3rd tibial tuberosity and PCL.

Workflow

Surgeon performs the preferred approach to the knee joint keeping knee in position with the help of a custom leg and thigh holder, trackers are installed on the femur and tibia. Then robot is connected with patient using a frame which is connected to two transverse pins in the femur and tibia. Anatomical landmarks are selected on the patient and is identified according to the pre-operative image. Further plans depicted by robot is shown on the screen. Milling is activated once the plan is approved by the surgeon. Surgeon can override the milling process if the necessity arises. After completion, final assessment with trial components and ligament balancing are done.

NAVIO

Make:
Smith & Nephew, acquired Minnesota-based Blue Belt Technologies and its handheld Navio system in 2016. London-based medical device company added a total knee arthroplasty application to Navio in 2017. It has acquired further technology for Navio through its acquisition of Brainlab's orthopedic joint reconstruction business on June 2019. It provides option of PFJ, UKA, TKA, bicruciate TKA.

Semi active –
This is a semi active robot, having option of a burr to execute its planning.

Image free –
It does bone sculpting using handheld instrument and intra-operatively using technology similar to OMNIBOT.

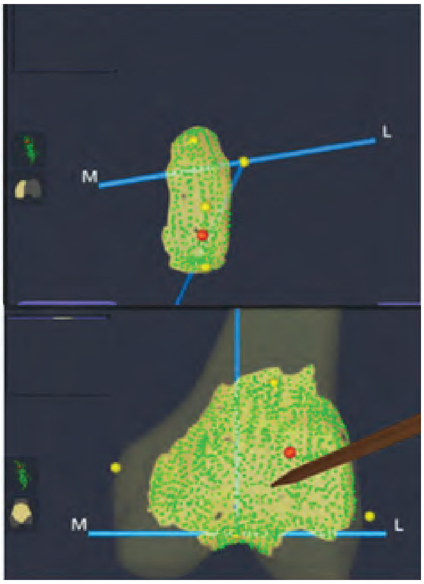
Implant compatibility
Only cemented implants, JOURNEY II portfolio, STRIDE UNI, Zuk UNI, GENESIS II portfolio, LEGION portfolio. PS, CR, Bicruciate options are available.

Device description
- Handheld robot – it gives 6-degree freedom within a stereotactic boundary
- Infrared Camera with cart contains electronic control system, an electrical system integration unit, a computer, an uninterruptible power supply, and a touchscreen monitor
- Two foot pedals controlling Anspach drill and control for assistant
- Headpiece

User interface
- Four primary interactive viewscreens used to manipulate the implant component, depicting sagittal, coronal, and transverse views to plan for the femur and tibia implants.
- Beneath those viewscreens is a graph from 0° through 120° of flexion. The x-axis represents the flexion (degrees). The y-axis represents millimetersof either the relative gap/laxity (+) or the over-lap/tightness (-) (Fig 18).
- Flexion or extension view
- ROM view

Setup requirement

Before bone registration it is recommended to remove ACL or both ACL and PCL.
Four tracking markers are required for each array and there must be 4 arrays, one each on femur, tibia, probe and handheld robot.
Checkpoints are attached on both femur and tibia, similar to MAKO. Which must be away from bony cut, which gives information regarding any movement of arrays from its normal place.
Hip center of rotation is detected with circumduction movement in which multiple points are collected displayed on the screen.
Ankle center is calculated from medial and lateral malleolus identification.
Have to give compressive force while taking knee in complete range of motion. It also provides status of ligament in terms of gap similar to MAKO and ROSA.
Have to collect multiple points on the bone surface, it gives additional information of marked mechanical and anatomical axis (Fig 17).
PCA is the default axis in this, but option of TEA and AP axis is also available.
There is no ligament balancing option in this, main modality is measured resection technique.



There are options of using all burr, distal burr and using femoral cut guides.
Two modes namely exposure control (active when burr outside desired cutting area) and speed control are present with maximum rpm of 80000.
Saw blade thickness is 1.35mm and all Navio TKA cut guides are designed to be secured with 1/8" diameter S&N Speed Pins with 5 mm cylindrical burr.

Workflow

Midline incision is used and knee is exposed, osteophytes and ACL, PCL and menisci are removed according to the implant and procedure to be done. Arrays are attached on femur and tibia with help of Schanz pins. Next step is registration of bone and bone mapping. Hip center is detected, and bony landmarks are identified, rest surface of bone is painted by collecting multiple points on image shown on the screen.

Checkpoints are made on femur and tibia to detect any abnormal movement of the arrays. Then with compressive forces knee is taken into complete range of motion and then with varus and valgus stress to assess the gaps available.

Then NAVIO software displays planning in terms of positioning of implant, mechanical alignment and amount of bone to be removed. Then if satisfied with the plan handheld robot is brought into the operating field with burr controls on within specific boundaries to execute the process. Then trial components used and reassessment is done through complete range of motion, if any change is required redoing the planned resection is an option.

Discussion

Total knee replacement remains a successful operation, and as we move towards a fitter and healthier global population and life expectancy is increasing, there is a surge in requirement for this procedure. Since its advent there has been multiple factors which have had an impact on its success.

Important factors which have been identified to cause patient dissatisfaction and early wear is implant positioning and failure to restore alignment. With time there has been improvement in technology from conventional instrumentation to Computer assisted Navigation and Patient Specific Instrumentation to address and improve implant alignment.

Current demands from clinicians is the requirement for precisely executing the surgical task after an opportunity to pre-plan surgical setups and then to deliver options for intra-operative adjustments based on validated alignment feedback and visual representation of soft tissue balance. This demand is being fulfilled by advancements in robotics.

Robotics is still taking small steps, as it is relatively new technology although the robotic TKR (ROBODOC) was first used quite early in 1992. Now we have multiple robotic platform options to choose from and in this paper, we have attempted to compare in the easiest possible way the different platforms available to the surgeon in 2021.

Robots are classified on the basis of level of collaboration between the robot and its operator, traditionally they are grouped into - passive, semi active and active. Passive robots just provide planning for the procedure, with no control on actual execution of the procedure, just like navigation. Semi active robots provide planning and then control the actual execution of the procedure within spatial boundaries, and most of the robots currently work on this principle having a robotic arm, like MAKO, ROSA, OMNIBOT and NAVIO. Active robots provide planning then actually control and perform segments of the procedure, under the supervision of surgeon, like ROBODOC.

There are other aspects to robotic technology such as image and image free. Image free systems allow all bone mapping to occur intra-operatively without having any pre-operative x ray or CT scan: NAVIO, OMNIBOT. Advantage of the image based technology based on pre-operative xrays or CT or MRI is that you can do pre-planning of the surgery determining implant sizes and organizing inventory as needed. Open and closed platform systems refers to the compatibility of the robotic technology with different implants or with a select range of implants specific to one company.

Most of the robots give information regarding flexion and extension gaps and gives option to balance the gap with bone resection, soft tissue releases and implant positioning, and OMNIBOT also gives actual gap forces in newtons individually for both medial and lateral compartments and how it changes over the whole range of motion.

Amount of information provided by robotic platforms at different stages is then saved as a data packet and the vast collection of metadata over time can be used in the future for a better understanding of knee biomechanics and differences between individuals. This will eventually help use to move towards a customized TKA in terms of individual alignment.

If one looked at the chronology and the developments, ROSA was recently launched (2019) by ZimmerBiomet, it is a semi active robot, which provides option of balancing gaps in flexion and extension using measured resection technique or flexion gap balancing technique determining femoral rotation. It has the option of both imageless and image-based planning with standardized plain X rays or MRI. Little published data is available, but a cadaveric study of 15 knees demonstrated highly accurate placement of implant and measured bony cut thickness (12).

MAKO was launched in 2015, a semi active robotic arm with saw attachment, which works in haptic boundaries. It provides real time assessment of bony cuts being made. UKA was launched before TKA and has shown promising results. Bell et al (13) concluded in their RCT of MAKO and manual UKA that there is increased accuracy of implant positioning in 120 patients with robot. Recently a comparative study of MAKO vs manual ZUK UKA has reported improved survivorship at 3 years. But there was high rate of infection in robotic group (14). Further better comparative studies are required with more variables, but nonetheless early results are promising.

OMNIBOT provides a balance bot which gives option of balancing gaps on the basis of equal force in both the compartments. There is option of proceeding with procedure without using the balance bot and just using the measured resection technique for implant placement. Currently only single paper is present which demonstrates proper ligament balancing after using this technology (15). APEX knee implants which have shown good implant survivorship at 10 years are compatible with this system. ROBODOC is the only fully active robot, it is one of the earliest robot technologies to be launched and has multiple papers showing good alignment and accurate implant positioning (16, 17,18). Song et al in their cohort studies has reported better HSS, WOMAC scores in comparison to conventional TKR, this may be attributed to better joint line recreation, because of better positioning of the implant (18,19).

NAVIO is a milling system, in which bone mapping is used to accurately execute the procedure. It has the maximum number of TKA implant compatibility but amount of published information present on user interface is less than its counterparts. There is no option to balance flexion gaps using a gap balancing technique. NAVIO system for UKA has shown good survivorship and accuracy in implant positioning in various studies (20,21,22).

ChumroonkietLeelasestaporn et al, in their recent study has compared NAVIO and MAKO for UKA in 33 patients and they have compared many functional, alignment and survivorship variables of both the platforms and concluded no difference in clinical and radiological outcome, but less operative time and bleeding was noticed in MAKO group (23). More studies like this are needed to assist in the selection of the best robotic platform for each procedure.

This paper is unique in the sense that there is still no paper comparing different robotic platforms, which explains basic terms and working of all the robots available in market. This can be used as a reference for selecting the correct option and what each robot is providing in terms of planning and execution.

On the basis of limited scientific data available to date, it is difficult to judge the superiority of one system over the other. But this paper attempts to explain the multiple options available to the clinician. The field of robotics is quite exciting and there is enormous potential in robotics to take arthroplasty further to the desired perfect outcome for each of outpatients.

	ROSA	**MAKO**	**OMNIBOT**	**ROBODOC**	**NAVIO**
LEVEL OF COLLABORATION	SEMI ACTIVE	SEMI ACTIVE	SEMI ACTIVE	ACTIVE	SEMI ACTIVE
ROBOTIC ARM	CUTTING GUIDE	SAW	FEMUR MOUNT	BURR	HANDHELD
IMPLANT COMPATIBILITY	CLOSED	CLOSED	CLOSED	OPEN	CLOSED
IMAGE OR IMAGELESS	BONE MAPPING, X RAY AND MRI	CT BASED	BONE MAPPING	X RAY AND CT	BONE MAPPING
USER INTERFACE PLANNING	PRE OPERATIVE, MEASURED RESECTION AND LIGAMENT BALANCING	PRE OPERATIVE, MEASURED RESECTION AND LIGAMENT BALANCING	MEASURED RESECTION AND LIGAMENT BALANCING	PRE OPERATIVE AND MEASURED RESECTION	MEASURED RESECTION
ARTHROPLASTY OPTIONS	TKA	TKA AND UKA	TKA	TKA, THA, REVISION	TKA, THR, UKA, BICRUCIATE
GAP ASSESSMENT	BONE CUT AND LAXITY SEPERATELY	BONE CUT	BONE CUT	BONE CUT	BONE CUT
FEMORAL ROTATION	ON BASIS OF SPACE IN mm	ON BASIS OF SPACE IN mm	SPACE IN mm AND IN NEWTON	NO OPTION	NO OPTION
SCIENTIFIC EVIDENCE	ONLY CADAVERIC	RCT MAINLY FOR UKA	ONE PAPER SERIES	MOST STUDIES	MANY COMPARATIVE STUDIES

References

1. Australian Orthopaedic Association National Joint Replacement Registry. Annual report 2019. https://aoanjrr.sahmri.com [accessed 28.08.20].

2. Moreland JR. Mechanisms of failure in total knee arthroplasty. Clin OrthopRelat Res 1988:49e64.

3. Hofmann AA, Bachus KN, Wyatt RW. Effect of the tibial cut on subsidence following total knee arthroplasty. Clin OrthopRelat Res 1991;269:63e9.

4. Freeman MA, Todd RC, Bamert P, Day WH. ICLH arthroplasty of the knee: 1968e1977. J Bone Joint Surg Br 1978;60-B:339e44.

5. Agarwal N, To K, McDonnell S, Khan W. Clinical and Radiological Outcomes in Robotic-Assisted Total Knee Arthroplasty: A Systematic Review and Meta-Analysis [published online ahead of print, 2020 Mar 11]. J Arthroplasty. 2020;S0883-5403(20)30234-5.

6. Chin BZ, Tan SSH, Chua KCX, Budiono GR, Syn NL, O'Neill GK. Robot-Assisted versus Conventional Total and Unicompartmental Knee Arthroplasty: A Meta-analysis of Radiological and Functional Outcomes [published online ahead of print, 2020 Mar 17]. J Knee Surg. 2020;10.1055/s-0040-1701440.

7. Bourne R, Chesworth B, Davis A, Mahomed N, Charron K. Patient Satisfaction after 274 Total Knee Arthroplasty: Who is Satisfied and Who is Not? Clinical Orthopaedics and 275 Related Research®. 2010;468(1):57-63.

8. Clement ND, Burnett R. Patient satisfaction after total knee arthroplasty is affected by 277 their general physical well-being. Knee Surgery, Sports Traumatology, Arthroscopy. 2013:1- 278 9. 279

9. Nam D, Nunley RM, Barrack RL. Patient dissatisfaction following total knee 280 replacement: a growing concern? Bone Joint J. 2014;96-B(11 Supple A):96-100. 281

10. Von Keudell A, Sodha S, Collins J, Minas T, Fitz W, Gomoll AH. Patient satisfaction 282 after primary total and unicompartmental knee arthroplasty: an age-dependent analysis. Knee. 283 2014;21(1):180-4.

11. Eymard F, Charles-Nelson A, Katsahian S, Chevalier X, Bercovy M. "Forgotten knee" after total knee replacement: A pragmatic study from a single-centre cohort. Joint Bone Spine. 2015;82(3):177-181.

12. Parratte S, Price AJ, Jeys LM, Jackson WF, Clarke HD. Accuracy of a New Robotically Assisted Technique for Total Knee Arthroplasty: A Cadaveric Study. J Arthroplasty. 2019;34(11):2799-2803.

13. Bell SW, Anthony I, Jones B, MacLean A, Rowe P, Blyth M. Improved Accuracy of Component Positioning with Robotic-Assisted Unicompartmental Knee Arthroplasty: Data from a Prospective, Randomized Controlled Study. J Bone Joint Surg Am. 2016;98(8):627-635.

14. St Mart JP, de Steiger RN, Cuthbert A, Donnelly W. The three-year survivorship of robotically assisted versus non-robotically assisted unicompartmental knee arthroplasty. Bone Joint J. 2020;102-B(3):319-328.

15. Shalhoub S, Lawrence JM, Keggi JM, Randall AL, DeClaire JH, Plaskos C. Imageless, robotic-assisted TKA combined with a robotic tensioning system can help predict and achieve accurate post-operative ligament balance. Arthroplasty Today, Published online Aug 13, 2019.

16. Liow MH, Chin PL, Tay KJ, Chia SL, Lo NN, Yeo SJ (2014) Early experiences with robot-assisted total knee arthroplasty using the DigiMatchTM ROBODOC® surgical system. Singapore Med J 55(10), 529–534.

17. Bellemans J, Vandenneucker H, Vanlauwe J (2007) Robot-assisted total knee arthroplasty. Clin OrthopRelat Res 464, 111–116.

18. Song EK, Seon JK, Park SJ, Jung WB, Park HW, Lee GW (2011) Simultaneous bilateral total knee arthroplasty with robotic and conventional techniques: a prospective, randomized study. Knee Surg Sports TraumatolArthrosc 19(7), 1069–1076.

19. Song EK, Seon JK, Park SJ, Jung WB, Park HW, Lee GW (2011) Simultaneous bilateral total knee arthroplasty with robotic and conventional techniques: a prospective, randomized study. Knee Surg Sports TraumatolArthrosc 19(7), 1069–1076.

20. Bollars P, Boeckxstaens A, Mievis J, Kalaai S, Schotanus MGM, Janssen D. Preliminary experience with an image-free handheld robot for total knee arthroplasty: 77 cases compared with a matched control group. Eur J OrthopSurgTraumatol. 2020;30(4):723-729.

21. Mergenthaler G, Batailler C, Lording T, Servien E, Lustig S. Is robotic-assisted unicompartmental knee arthroplasty a safe procedure? A case control study [published online ahead of print, 2020 May 10]. Knee Surg Sports TraumatolArthrosc. 2020;10.1007/s00167-020-06051-z.

22. Battenberg AK, Netravali NA, Lonner JH. A novel handheld robotic-assisted system for unicompartmental knee arthroplasty: surgical technique and early survivorship. J

Robot Surg. 2020;14(1):55-60.

23. Leelasestaporn C, Tarnpichprasert T, Arirachakaran A, Kongtharvonskul J. Comparison of 1-year outcomes between MAKO versus NAVIO robot-assisted medial UKA: nonrandomized, prospective, comparative study. Knee SurgRelat Res. 2020;32(1):13.

Orthopaedic online learning: Is it here to stay?

Dr Kukuh D. Hernugrahanto

Learning is defined as the acquisition of knowledge or skills through study, practice, and experience. According to Edgar Dale's cone of experience, successful learning requires the combination of reading, hearing, seeing, and doing. The medical field, particularly surgery like orthopaedics, requires not only textbook knowledge but also clinical judgment and practical skills to approach patients as human beings. To fulfill the requirement of reading, hearing, seeing, and doing, person-to-person teaching has been the mainstay method that demands physical attendance and contact between mentors and mentees. For over a year, we realize that the COVID-19 pandemic has changed most aspects of our life, including education and training. The situation has changed, but the demands of knowledge and skill transfer remain the same. At the beginning of the pandemic, people are forced to work or study from home and maintain social distancing. Scientific meetings, surgical skills training, and workshops are put on hold. Fortunately, technological advancement has made distant online learning possible. There was a steep rising in online webinars and workshops to accommodate orthopaedic surgeons and trainees' need to stay updated. Online meeting platforms also gained immense popularity to accommodate scientific meetings and lectures. After more than a year, as the pandemic situation has improved, with the distribution of vaccines and relaxation of activity restriction, people have resumed work and school under the New Normal. The questions are: Will online learning still be around after the pandemic? Is the convenience of online learning going to replace classical in-person education?

Online learning: How we become conveniently accustomed to

Distant learning had been around long before the COVID-19 pandemic. Transfer of knowledge using digital content in electronic textbooks, online articles, and surgical videos had become widespread. It allowed affordable and accessible learning opportunities to any surgeons and trainees in any part of the world. Recorded lectures and surgical videos have been uploaded to popular video-sharing platforms for timeless access. These provide the opportunity for us to learn by reading, hearing, and seeing conveniently.

When the pandemic hit us hard last year, we had been familiar with digital and distant learning. Still, we needed a slight adjustment to install the apps and get used to online platforms. Once everyone has gotten used to it, scientific meetings have been converted to online webinars. Cadaveric workshops and live surgery have been broadcasted through the online channel. Classical lectures have been carried out on online meeting platforms as well. Attendance in multiple scientific meetings has now become possible from your desk. It is so convenient that we may listen to a kinematic alignment lecture by a big name in the US in the morning, then we switch to a live robotic surgery in one Asia-Pacific country in the afternoon and attend the case discussion of a European hip society in the evening. All are made possible just by a click or a tap on our screen. This flexibility also does not require the necessary air tickets and accommodation fares as we previously have to allocate. Therefore, we all agree that online learning offers flexibility and affordability.

Online learning: Things we still expect to have

As agreed in the beginning that learning requires doing, especially in surgical skills. We have to admit that this online learning lacks one essential element: tactile feedback. Cadaveric workshops and live surgery only provide us with the opportunity of seeing and hearing things. To be skillful enough, a surgeon has to experience the tactile feedback of hands-on practice. The conventional cadaveric workshop needed to improve motoric skills in a safe environment has been postponed. The development of virtual reality (VR) and augmented reality (AR) to replace the cadaveric workshop provides a simulated and immersive three-dimensional environment to resemble the realistic surgical environment. VR and AR can enhance the training experience by helping the surgeon with constructive learning combined with a safe environment for making mistakes. Still, this technology has not provided the surgeon's necessary tactile feedback to experience the actual patient situation. The ease of attending meetings on online platforms offers us the opportunity to interact with any surgeons worldwide. However, the computer screen will not allow one privilege that humans, as a social being, long to do: physical in-person interaction. The luxury of attending a lecture or discussing a case over a cup of coffee with colleagues is something we all long to do. This face-to-face interaction and conversation is something we have to bear not to experience during the pandemic.

So, is online learning going to stay?

The answer is yes, to a certain extend. The ease of knowledge transfer over the computer screen will still be a preferred choice even after the pandemic has passed. It offers the luxury to read, see, and hear new information from all over the world right on our laptop, but to some extends, online learning may not provide everything. We believe that in-person learning is still the mainstay of teaching as it offers things that online learning cannot do: tactile experience and physical interaction. Our attachment with technology would remain even if the pandemic disappeared today. Technology has provided ease and redefined us. Things that seem to be awkward at first will become somewhat a new normal.

When the pandemic situation permits people to attend the regular meeting again, we believe that people will leave their comfortable desk to travel and seek knowledge. After all, even when technology and situation change, we remain human, a social being that keeps learning and needs social interaction.

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References

1. Dale E.Audio-Visual Methods in Teaching, 3rdEd. New York: Holt, Rinehart & Winston; 1969:p.108

2. Stambough JB, Curtin BM, Gililland JM, Guil GN, Kain MS, Karas V, Keeney JA, Plancher KD, Moskal JT. The Past, Present, and Future of Orthopedic Education: Lessons Learned From the COVID-19 Pandemic. J of Arthrop, 2020;35:560-564

3. Plancher KD, Shanmugam JP, Petterson SC. The Changing Face of Orthopaedic Education: Searching for the New Reality After COVID-19. Arthrosc Sports Med and Rehab, 2020;2(4):e295-e298

4. Sleiwah A, Mughal M, Hachach-Haram N, Roblin P. COVID-19 Lockdown Learning: The Uprising of Virtual Teaching. J PlastReconstrAesthet Surg, 2020;73(8):1575-1592

Virtual APAS Conference 2021

Dear APAS Members

With many affected by the Covid 19 pandemic, I wish only that you and your families keep safe until we defeat this affliction. Because of the global restrictions the planned annual scientific meeting in Bali for this year has again been deferred until 2022. In the interim and to serve our members the executive has decided and progressed substantially with planning for the 21st ASM of APAS as a Virtual conference in July. This will be a 3-day conference held over 3 consecutive Saturdays to maximise your attendance and participation. Time zone issues are always difficult in the virtual space and to accommodate the region the conference will run between **Midday to 8pm AEST (UTC/GMT +10)**. The dates of the conference this year will be **Saturday 10th, 17th and 24th July.**

The virtual platform we have selected will allow a high level of interaction and involvement for delegates as we will run 2 concurrent auditoriums for hip and knee arthroplasty and a virtual foyer and exhibition booths which will allow interaction with the trade display and industry (there may be some limitations in some countries with the virtual space technology, but the zoom presentations and surgical videos should be accessible by all).

Academic content will see a wide and highly regarded faculty from around the globe ready to deliver great content to you on the theme of the conference: **"Arthroplasty in the Age of Technology"**. The highlight of this conference will be access to up to 12 live surgical procedures which will be live streamed into the program from operating theatres in Sydney, Perth, Gold Coast, Auckland, Pune, Mumbai,Urumqi and Beijing. Surgery will include primary TKA using different robotic technologies and different alignment strategies, primary THA using different approaches and pre-operative planning strategies, revision THA with robot assist and revision TKA for PJI with one stage technique. Didactic presentations will also focus on video demonstrations to share with you our approach to procedures you deal with daily as well as the more complex situations which will be debated and discussed among our panel of experts.

The webpage for registration and information will go live on May 1 and abstracts for free paper presentations will be accepted up until mid-June, so prepare your scientific submissions if you wish for your work to be part of this conference. The webpage can be reached via our home page at **www.apasonline.org** or directly at **www.apas2021.com** This will be a major undertaking for APAS who will be joined by our friends and colleagues from ASIA and APKS for this conference as well as colleagues from further afield. As this whole conference will be virtual, we have the opportunity to share and welcome delegates from anywhere on the globe to join us for this conference and I hope you plan ahead and put some valuable time aside for this highly anticipated online feast.

Best regards and keep safe

A/Prof. Rami Sorial
Scientific Chairman APAS

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