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EDITORIAL

Anatomical versus mechanical joint reconstruction: time to pick your surgical philosophy!

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Following the relatively recent introduction of hip and knee replacement approximately half a century ago, the rate of improvement has been fast with both more sophisticated surgical techniques and implants. Initial efforts were focused on reducing severe complications and securing implant longevity through the development of hardwearing bearing surfaces, biological fixation, and precision tools (e.g. computational assistance), in addition to optimising surgical approaches towards less invasive techniques. Although patient satisfaction was high, a ceiling effect was observed [3, 4, 9, 18]. As a consequence, and in parallel to recognising that every joint is unique (tri-dimensional anatomy, laxity, and biomechanics) and could benefit from being addressed individually [2, 5, 7, 8, 10, 16], clinicians started to review the fundamentals of joint replacement, ultimately questioning the definition of optimal component positioning [12–15].

There are two opposing philosophies for implant positioning: the 'anatomical' approach, whereby the goal is to preserve the anatomy and biomechanics (unless aberrant) of the native joint as much as possible; and the 'non-anatomical' or 'mechanical' approach, in which implants are aligned relative to extra-articular landmarks that have no relationship with the native anatomy of the implanted joint. Figures 1, 2, and 3 illustrate the evolution of alignment techniques for total knee (TKA), unicondylar knee (UKA), and total hip (THA) arthroplasty.

The systematic mechanical implantation technique has been the most popular method by which to perform hip and knee arthroplasty. This is primarily explained by the simplicity of a 'standardised technique'—implant orientation is identical in all patients. In the early phases of arthroplasty, when both instruments and implant design were rudimentary (e.g. first primary TKA implants had a stemmed hinged design), it was unrealistic to try to restore the individual joint anatomy. Furthermore, the understanding of joint biomechanics and the pathophysiology of osteoarthritis was poor, with the general belief that joint anatomy was one of the main determinants of osteoarthritis and thus should not be reproduced.

Decades of research have validated the long-term survivorship and acceptable functional performance of systematic implantation techniques for arthroplasty [1], however limitations have also been highlighted via this process (systematic errors) [3, 6, 18]. Notably, the orthopaedic community has only recently recognised the deleterious clinical impact of altering the physiological anatomy, laxity, and biomechanics of a joint. In parallel, performing more physiological implantation now seems more reasonable; it is allowed by modern hardwearing and solidly fixed implants which resist substantial stresses in addition to the availability of technological assistance for the planning and precise execution of arthroplasty. This has reignited interest in the anatomical approach and led to the development of promising personalised alignment techniques for both hip and knee arthroplasty [12, 13, 15–17, 20].

The newest generation of arthroplasty surgeons are now facing a dilemma at the beginning of their career; they must embrace either 'anatomic' or 'mechanical' approaches; as well as personalised or systematic implantation techniques. Young surgeons should make the most of the many opportunities that are presented to them (e.g. fellowships, visiting expert surgeons, cadaveric courses, video channels) to satisfy their curiosity and choose their

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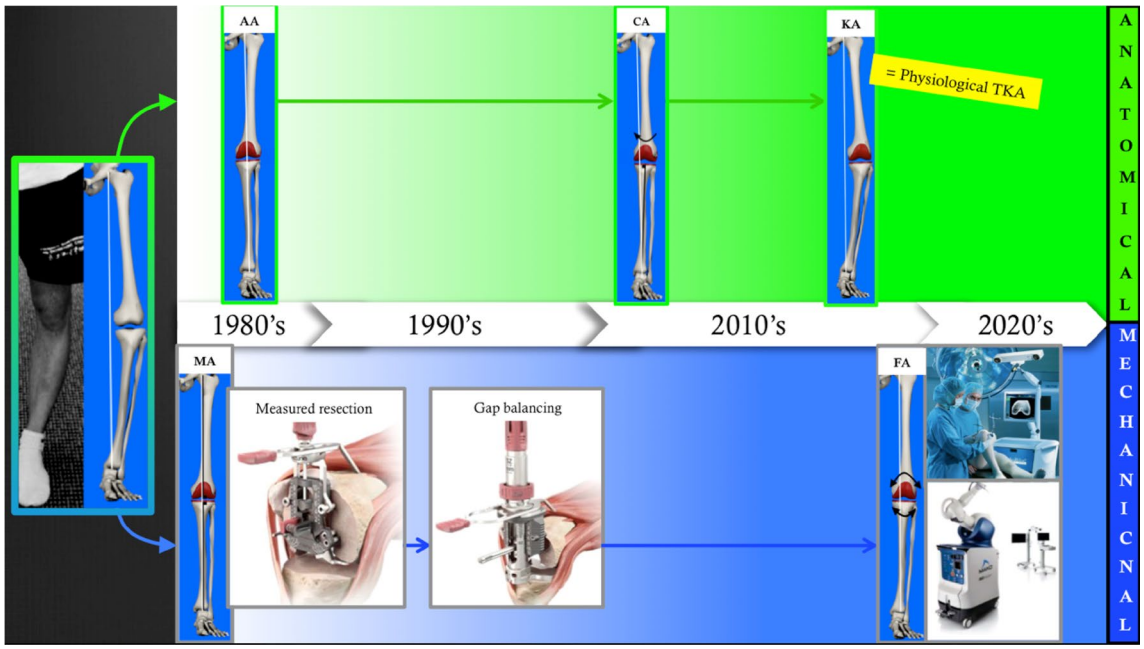

Fig. 1 Evolution of total knee replacement surgical techniques [17]. Mechanical approach: initially, the mechanical alignment (MA) technique was primarily performed using a measured resection approach, the goal of which was to optimise patella tracking. This then evolved to a gap-balancing technique (personalisation of the axial rotation of the femoral component) in order to optimise soft-tissue balance at 0° and 90° of knee flexion. The most recent development of the mechanical approach is illustrated by the technology-driven functional alignment (FA) technique, of which the objective is to align the lower limb and balance the prosthetic knee through the entire range of motion. Implant alignment is personalised to generate symmetrical gaps in flexion and extension; however, this is done within a limited range. Anatomical approach: the anatomical alignment (AA) technique acknowledges that the mean knee joint line is approximately 3° oblique, and thus recommends a systematic femoral cut at 3° valgus and a tibial cut at 3° varus. The constitutional alignment (CA) technique for patients with medial osteoarthritis, also known as 'adjusted MA', aims to generate 2°–3° of varus limb deformity systematically for patients with medial osteoarthritis. Keeping a neutral tibial cut, the technique recommends increasing the varus angle of the femoral cut. Both AA and CA are systematic techniques (i.e. not personalised). The kinematic alignment (KA) technique (also known as the 'physiological technique') aims to recreate the pre-arthritic joint anatomy in all 3 planes, thus reproducing close-to-physiological knee laxity and biomechanics. By resurfacing the joint surfaces, native ligament laxities and function are maintained. Due to concern that some anatomies or pathoanatomies may be detrimental for KA TKA, the concept of restricted KA (not illustrated) was developed, which provides some pre-defined boundaries when reproducing patients' anatomy

own path, which eventually, will be dictated by the scientific evidence. Attempts were made to compare outcomes between the standard mechanical and modern fashions for TKA [19], UKA [15], and THR [11], overall concluding at promising results with personalized techniques. We believe the anatomic approaches' favourable outcomes in the short and medium term will endure in the long term and henceforth, we endorse its wide adoption. In this period of reappraisal, confusion may occur and high-quality research for comparing the values between options is of primary importance to guide the choice between anatomical and mechanical joint reconstruction.

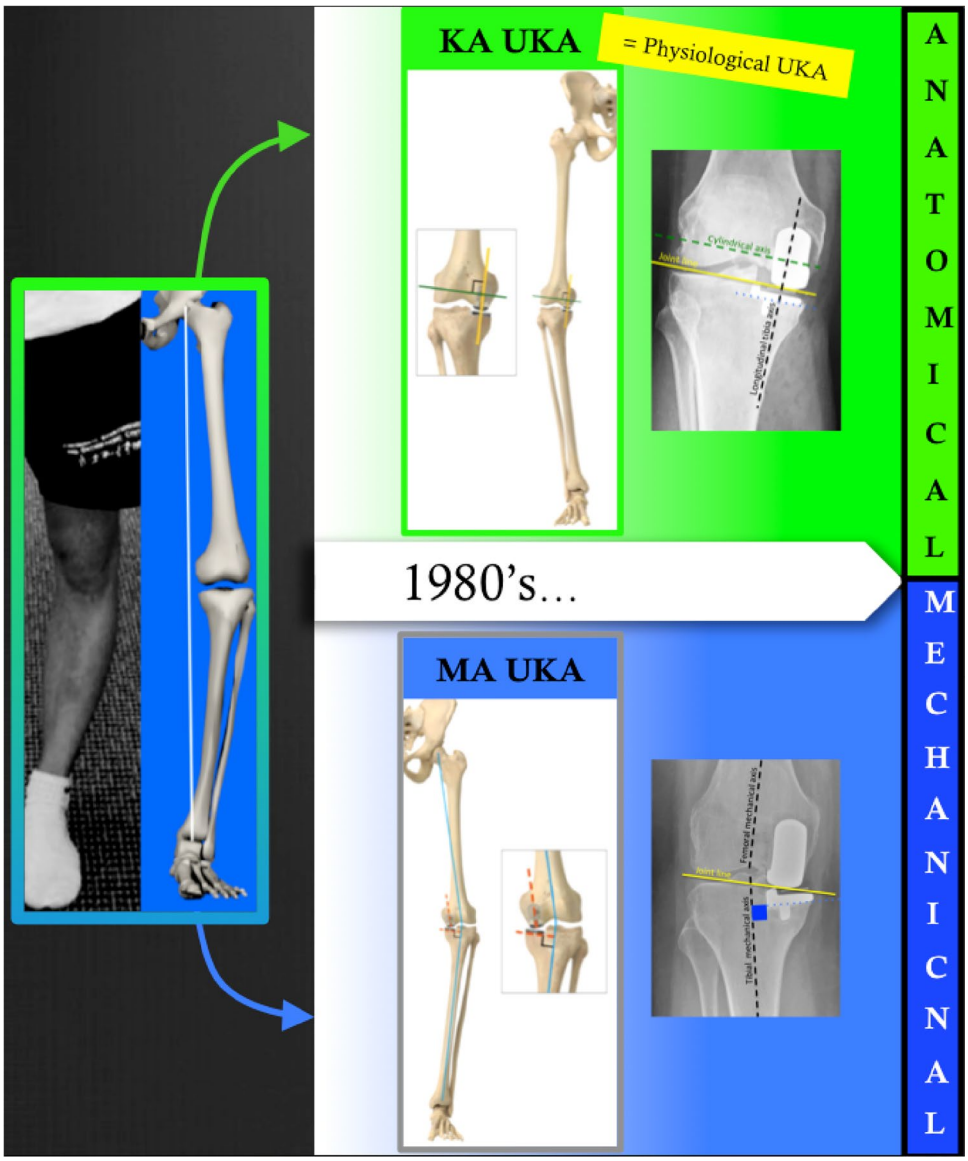

Fig. 2 The anatomical and mechanical approaches for partial knee replacement [15]. The Mechanical alignment (MA) technique systematically implants prosthetic components in the frontal and sagittal planes alongside mechanical axis of the long bones. The kinematic alignment (KA) technique (also known as 'physiological technique') intends to recreate the pre-arthritic knee compartment anatomy in all 3 planes, thus reproducing close-to-physiological knee laxity and biomechanics

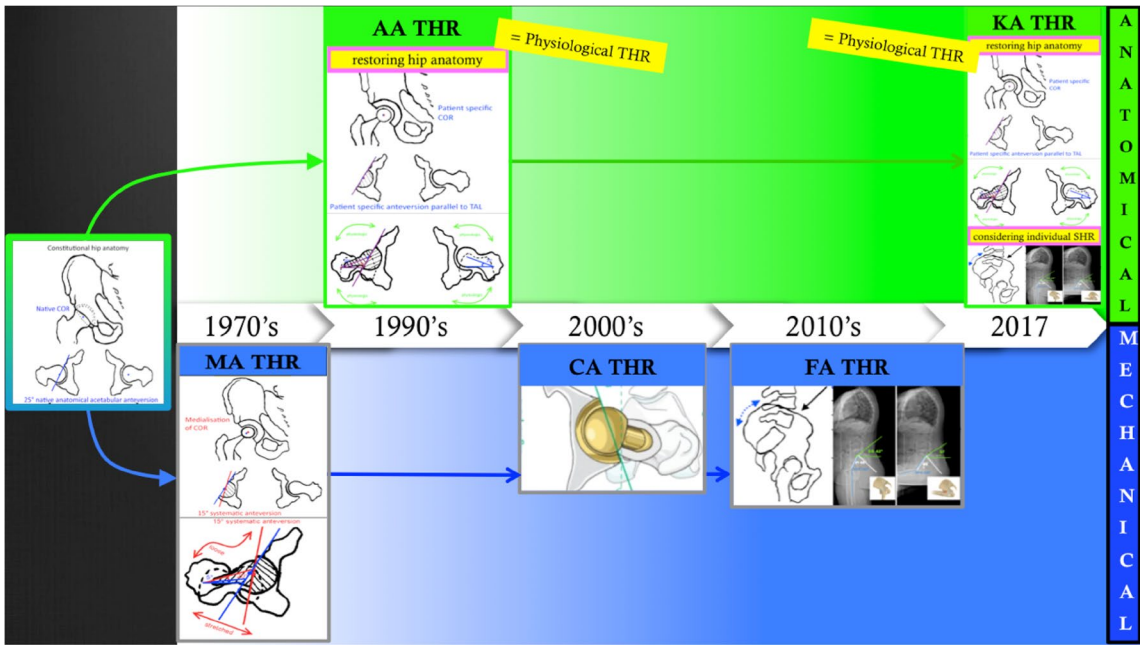

Fig. 3 Evolution of total hip replacement surgical techniques [14]. Mechanical approach: it is generally felt that this started with John Charnley's low frictional torque arthroplasty technique, at a time when reducing wear on bearing surfaces was a priority. The technique involved the use of a non-anatomical 22.2 mm bearing and recommended reducing the joint reaction forces through the medialisation of the centre of rotation of the hip. Furthermore, surgeons systematically aimed to produce femoral stem anteversion relative to the posterior condylar line of distal femur, and a cup orientation of 20° of anteversion relative to the anterior pelvic plane (APP). The Lewinnek safe zone was used to assess the accuracy of implant orientation. The combined anteversion (CA) technique entails replacing the femoral side first, then using the femoral stem anteversion as a guide to match the cup anteversion to it. Moving away from a systematic approach, the FA technique takes the functional (or dynamic) orientation of the acetabulum (dictated by spinal' standing alignment and flexibility) into account, in addition to employing the CA principles. Both the CA and the FA techniques are personalised but non-physiological, in that there is no purposeful attempt at recreation of native femoro-acetabular interplay and soft-tissue tension. Anatomical approach: the anatomical alignment (AA) technique strives to restore the pre-arthritic hip anatomy, unless aberrant (e.g. Perthes disease). Some advocates of AA suggest using anatomical femoral head diameter with hip resurfacing or large diameter head THA implants. The KA technique follows the same principles as AA but additional takes the functional orientation of the acetabulum into consideration. Both the AA and the KA techniques are personalised and physiological, with the aim being to alter the native joint biomechanics as little as possible. Both the FA and the KA techniques take the functional orientation of the acetabulum into account; when an adjustment of the cup orientation is needed, this is respectively done relative to the orientation of the APP for FA and the transverse acetabular ligament for KA

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Conflict of interest Charles Rivière is a consultant for Medacta; Loïc Villet is a consultant for Medacta, Gabriel Bouchard Roby has no conflict of interest to declare.

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