From radiographs to 3D printing: How can new surgical planning technologies contribute to hip surgery?

When a surgeon plans a surgical procedure, he is fulfilling a medical, moral and soon, a regulatory responsibility, in the continuing search to minimize surgical risks. While radiographs have historically been used in orthopedic and trauma surgery, digital tools and 3D printing have become more diverse and more popular in both arthroplasty and trauma applications. Such applications have been highlighted in five articles grouped in this issue of our journal justifying this editorial.

For total hip arthroplasty (THA), it has become increasingly important to restore the “normal” anatomy to improve the functional outcomes in patients who are increasingly demanding, especially with greater adoption of minimally-invasive approaches [1]. This concept is controversial. For example, attempts at reproducing femoral offset have not led to better clinical outcomes; however, it did reduce polyethylene wear [2]. Since the 1970s, radiographic planning has mainly been performed with templates on an A/P view of the pelvis as described by Maurice Müller [3]. This has several limitations, such as the magnification factor, pelvis position, femur position and patient's position (lying or standing). The reproducibility varies and is often found to be poor. Despite use of standardized radiographic procedures, it is difficult to accurately plan the procedure in patients with non-reducible rotation or to anticipate certain surgical problems at the proximal femur or the acetabulum [4,5]. Additional steps in radiographs such as those described by Wang et al. [6] can help to improve the planning accuracy.

CT-scans can be used to get around these limitations [7]. Three-dimensional (3D) planning of THA procedures has been available for more than 20 years. This tool can be used to evaluate the femoral prosthetic helical torsion (axis in which femoral stem will be placed) and femoral anteverision (femoral neck axis), and to calculate the 3D offset. Based on the desired final prosthesis anteverision axis, the difference between the proximal femoral anteverision axis (or femoral helical torsion) and the target prosthetic anteverision axis can be calculated and the best implant selected. The femoral helical torsion can be extremely variable in secondary hip osteoarthritis (OA) cases or be near normal on average in primary hip OA, but have considerable individual variations [8].

The low-dose biplanar EOS system can be used to analyze the entire legs clinically with patients receiving less radiation than with standard radiographs. While it has been available for many years, it is still not as widely used as CT-scans. Specialized software can be used to generate a 3D model of the lower body skeleton and to extract clinical parameter such as femoral anteversion with the same reliability as CT-scans. In a radiological and anatomical study of lower limb acquisitions with the EOS system, the intra-class correlation was very high for analyzing tibial and femoral anteverision [9]. Studies of 3D planning for THA with the EOS system have been initiated. The initial results reported by Maimard et al. [10] were encouraging and could result in this tool become as popular as CT-scans.

Trauma surgery procedures can also be planned with computerized tools, particularly when treating complex lesions such as acetabulum and pelvis fractures. These tools aim to improve the diagnosis of fractures and to help the surgeon think ahead about the surgical approach and hardware needed as underlined by Upex et al. [11]. The reproducibility of 2D analysis is lacking; no method provides a direct link between Letournel's radiological classification system and CT-scan images [12]. Now dedicated 3D planning software with femur subtraction is available; promising results have been described by Jouffroy et al. [13]. In this context, having access to this information in the operating room could be valuable: 3D-printed bone models can be used in complex cases, such as some osteotomies or pelvic fractures [11,14]. Migaud et al. [15] used this type of tool when preparing for a complex proximal femur osteotomy procedure back in 1997. Three-dimensional printing has also been used for manufacturing instruments [16], tools [17] and surgical implants [18].

Computerization of our discipline is an inescapable fact. It appears desirable and in any case, inevitable. While we wait for big data [19] and robotics [20] to have a major impact on the field, it is evident that 3D is a major step forward for analyzing a patient's anatomy, planning the procedure and providing the specific tools and implants needed for each situation.

Disclosure of interest

Xavier Flecher declares that he has no competing interest; however, he is a consultant for Zimmer and Stryker. Henri Migaud declares that he has no competing interest; however, he is an associate editor for Orthopaedic Traumatology Surgery and Research, and is a consultant for Zimmer, Corin-Tornier, SERF and MSD.

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