How is 3D imaging impacting orthopedic treatments?

"If we want a 'real' evaluation of our work, we need 3D imaging. Moreover, most of orthopedic pathology depends on the impact of gravity. So we need 3D imaging in the standing position."

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We have not experienced great evolutions in the field of orthopedic surgery during the last decade. We have reached a threshold in terms of devices such as joint replacements, screws and nails. However, the business continues and each orthopedic brand claims to achieve better results than the others. Objectively, designs are equivalents and we no longer are surprised when opening the boxes of an ancillary; maybe companies do not want surprises either and are slowing down their R&D efforts? Or maybe we are leaving the 'iron age' and heading to a 'new age' and a new way of thinking about orthopedic surgery: biomaterials, conservative treatments, prevention, and so on.

But before we get to new device evolutions, the main issue in orthopedic surgery is to distinguish the proper indications, improve the planning of surgery and evaluate the clinical and radiological outcomes. The most difficult part is to reach objectivity, which is a problem in the world of orthopedic surgery because self-esteem is usually hypertrophic. We are not magicians; we need help in making the right decision and evaluating what we do. From my point of view, 3D imaging in the standing position is the main evolution that will impact planning and evaluation of orthopedics treatments.

Biplanar stereoradiography was initially developed for analysis of spine deformities. In the early 1980s, Perdriolle [1], Graf and Dubousset [2] first described adolescent idiopathic scoliosis (AIS) as a 3D deformity. Then clinicians and engineers worked hand in hand to improve stereoradiography imaging systems in the standing position. But we had to wait for the 21st century and the work of Georges Charpak (who received the 1992 Nobel Prize in Physics) to reach technologies such as EOS (EOS-imaging). EOS is a low-dose imaging system that performs simultaneous full-spine or full-body antero-posterior (AP) and lateral views. With special software, a 3D reconstruction of the spine and lower limbs is possible. 3D is available routinely, but now that we have 3D, we have to learn how to use it. It is a very new way to see the body from the inside, and since every orthopedic surgeon has learned their profession on 2D x-rays, we need to build novel references.

■ Why is 3D so essential?

We are all working in 3D. If we want a 'real' evaluation of our work, we need 3D imaging. Moreover, most of orthopedic pathology depends on the impact of gravity. So we need 3D imaging in the standing position. However, the devices by themselves will not solve all our problems, they are just tools. We have to learn how to use them. In my opinion, the great evolution is that we are now able to collect calibrated numerical data, accurate and reproducible 3D reconstructions before and after a surgery. It is a gold mine in which we could search for more evidence-based surgery.

3D has already improved our knowledge, particularly in the field of spine deformity. During the last decade, efforts were focused on spinal deformities and particularly on AIS. Spine deformities are indeed heavily influenced by gravitational forces. So having 3D imaging in the standing position was a dream, which has come true for most researchers on AIS with EOS [3]. With the latest EOS software, we can obtain a fast, accurate and reproducible 3D reconstruction of the spine. Engineers are now working on a full automation of the process of reconstruction, which will be 'a click away' in the coming years. For example, we have demonstrated that a progressive scoliotic curve had a specific 3D pattern that could be detected early before the progression of the Cobb angle [4]. Because each step towards progression is a point of no return,

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these results could lead to an earlier treatment of patients with expected progressive curves.

We do not know how to heal AIS. So our goal is to stop the evolution of the curve during the growth. But one of the main issues considering AIS management is to predict the effect of a treatment. We have demonstrated that the 3D effect of a brace treatment is highly variable [5]. Skepticism around the efficacy of brace treatment is a consequence of a general lack of knowledge of what is the real 3D effect of a brace on a specific curve pattern. We know that braces are efficient in many cases, but also worsen the sagittal balance or vertebral rotation in others. 3D Imaging of the spine will be a great help in understanding what the true effect of a brace is.

Surgical planning for AIS is also controversial. There are numerous publications on what level needs to be instrumented. Surgeons have tried to empirically classify the different types of curves in order to standardize the surgical treatment. From 2D classifications we have reached 3D classifications. Sub-groups have been identified. But problems persist: adding-on in Lenke 1A curves, the controversy around selective thoracic fusion or not in Lenke 1C curves or choosing the better approach, and so on. If we want to solve these problems, we need to collect accurate and reproducible data. Ideally, if we could have 3D reconstructions of each operated spine before and after surgery, we would construct a huge homogenous database, which could lead to a better understanding of what is really happening in the three planes. But most actual clinical studies on the impact of surgical treatment are retrospective data, based on 2D radiographs. The transverse plane is always missing.

Besides evolution of 3D reconstructions of the spine, lower limb surgeons have raised concerns about 3D reconstructions of the pelvis and lower limbs, which have recently been validated [6]. 3D evaluation of the pelvis before and after surgery could improve the implant positioning. 3D also provides better lower limb measurements, independent of the joint position, that are necessary for almost every lower limb surgery.

Imagine a future where we routinely have the patient's specific 3D geometry implemented in parametric numerical models. Imagine that all 3D pre- and post-operative numerical data collected all over the world could continuously feed into the parametric models. It is not science fiction; it is what could be possible with 3D imaging during the next decade. I am probably optimistic. But 10 years ago we were not even able to imagine the smartphones we have now in our hands.

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