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EDITORIAL

Importance of balance and profile in adult spinal reconstruction

Marco GA Teli

Marco GA Teli, Department of Orthopaedic Surgery, Civile Regional Hospital, 20025 Legnano (Mi), Italy
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Correspondence to: Marco GA Teli, MD, Department of Orthopaedic Surgery, Civile Regional Hospital, via Papa Giovanni Paolo II, 20025 Legnano (Mi), Italy. marcoteli@hotmail.com
Telephone: +39-331-449828
Fax: +39-331-449593
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Abstract

Long before its current understanding, the concept of balance was common among spine surgeons dealing with deformities, but it was a hard one to transfer to clinical practice. Thanks to the pioneering work of Duval-Beaupere and followers, the idea of balancing the sagittal contour of the spine has gained scientific status and is now in the armamentarium of the skilled surgeon as the single most important tool to achieve superior clinical results in adult spinal deformity surgery.

Key words: Sagittal balance; Sagittal profile; Adult spinal deformity; Anterior fusion; Posterior fusion

Core tip: Adult spinal reconstruction is set to become the emerging trend in the next years in spinal surgery. Failure of restoration of adequate spinal balance and profile in the sagittal plane is now recognised as the single most important factor determining inadequate improvement in quality of life in adult patients undergoing reconstructive surgery for spinal deformity.

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INTRODUCTION

Twenty years ago the concepts of pelvic tilt and incidence were scholar work for researchers who did not seem to have a solid grip on clinical matters[1]. Time, though, brings clarity to scientific matters. It became progressively apparent and accepted that patients undergoing fusion for degenerative deformities did not do well when their sagittal rather than coronal balance was less than restored[2]. Alleged reasons for these failures included natural history[3], junctional degeneration[4] and bone-implant interface failure[5] to name a few. It was only when surgeons started to learn the rules of spino-pelvic parameters and to apply them to patients that reports on adult spinal deformity surgery changed their grim faces into a more optimistic appearance[6].

The spinal community is set to be invaded by

ageing patients who demand increasing performances as their life expectancy and, sadly, the prevalence of their acquired deformities both increase. While the current scenario is dominated by the obsessive research of balance through the use of spinal osteotomies[7], the next will see the research of lesser invasive methods of anterior and posterior reconstruction that would not be at the expense of obtaining a solid and lasting fusion[8]. Open questions are issues about costs and complications of this most complex aspect of clinical medicine[9-11]. Aim of this paper is to set the scene of current and future trends in adult spinal deformity (ASD) surgery by analysing the potentially most important recently published papers on the subject.

We analysed English edited papers on ASD surgery through PubMed in the years 2000-2014 with attention to parameters that closely related to surgical outcomes[2-9]. Eleven papers were included in the analysis because of their clinical relevance to the subject[2-12]. All of them are retrospective case series or reviews limiting the value of their evidence to lower levels. Nevertheless, they represent the current golden standard of practice and the basis for future trends.

Criteria to include these papers in the analysis included: (1) Minimum follow-up of one year; (2) Objective quality of life measurements performed preoperatively and at follow-up; (3) Description and rating of complications into major and minor ones; (4) Description of type and site of osteotomies; and (5) Description of preoperative and follow-up sagittal spino-pelvic measurements.

Despite the variability of inclusion criteria on age, comorbities, severity of deformities and surgical techniques, the one issue that becomes apparent from the analysis of this literature is the obsessive description of spino-pelvic parameters as the most important feature correlating with clinical results.

The methods to achieve postoperative balance which are described in the papers include posterior wedge (chevron like or Ponte or Smith Petersen) osteotomies in case of non-rigid deformities with mobile discs; pedicle subtraction osteotomies and/or vertebral column resections in case of severe and rigid deformities and anterior or lateral interbody fusion techniques to improve the chance of a lasting correction of the deformity.

DISCUSSION

The group of Duval-Beaupere were the first to conceive the importance of pelvic parameters in the sagittal profile of the spine[1]. Before this paper gained widespread acceptance, most surgeons dealing with adults as well as paediatric deformities only concentrated on the coronal profile of the spine as a marker of their efforts. This is just one of the many possible examples of how tradition and lack of evidence may impair the practice of medicine. Fortunately, the translation of this pioneering work into practical guidelines led to increasingly common reports on how the sagittal profile impacts on daily living of affected patients, and this trend does not seem to stop on either sides of the Atlantic Ocean[2,3,9].

Many are the parameters of spinal balance described so forth[4], but three deserve particular attention, *i.e.,* Pelvic Incidence (PI), Pelvic Tilt (PT) and Sacral Slope (SS).

PI represents the width of the pelvis as seen on a lateral radiological view. PI is a fixed parameter for every person at the end of skeletal growth and determines the possibility of the spine to accomodate for degenerative changes that occur with ageing. PT represents the possibility of the pelvis to rotate on the femoral heads to accomodate for these changes. During backwards rotation, the PT increases and this movement is known as pelvic retroversion, while the opposite rotation is known as anteversion. Both retro and anteversion influence the SS, *i.e.,* the inclination of the sacrum in relation with the ground. PI, PT and SS are in mutual relationship according to the following equation: PI = SS + PT.

For instance, a PI higher than the average 52° predisposes to degenerative spondylolisthesis while a lower PI may lead to early degenerative disc disease and disc herniation (for full explanation of these features please refer to the paper by Rossouly and Nnadi[4]). On a practical ground, one of the lessons to be learned is that fusion of the lumbar spine should aim at a value of Lumbar Lordosis (LL) at least equivalent to that of PI or within 9 degrees of it[2,4]. Another important concept is that balance and profile should never be confused. A balanced spine is one that keeps its equilibrium without undue muscular efforts, pain or deformity, irrespective of its profile.

In fact, the sagittal profile of healthy adult volunteers has been studied and sub-classified into four types according to the level of the inflection point between the thoracic and the lumbar tracts of the spine[4]. These four types are rather simple keep in mind and should be used as a reference template in planning osteotomies and correction of ASD, in order to respect the original shape, *i.e.,* profile, of the individual spine[3,4]. In a simplistic way, the last important concept is that 70% of all lumbar lordosis, irrespective of the spinal profile, is concentrated between L4 and S1. As these levels are the ones that are most commonly addressed by surgical reconstruction, failure to recognise and restore any loss of lordosis would inevitably lead to spinal imbalance and trigger decompensation with aging[3].

Means to achieve the above goals are without any doubt advanced imaging techniques like EOS, a revolutionary tool using slot scanning low emission X ray bidimensional representations of the deformed spine and of the relative spinopelvic parameters[10]. EOS is able to record simultaneously postero-anterior and lateral X ray images allowing for tridimensional

reconstruction if desired. Another important feature is the ability if EOS to acquire full lenght bodily images, avoiding the need to stitch multiple images as needed in traditional X ray pictures. The quality of EOS pictures is similar to digital radiography and in tridimensional reconstructions it allows multiplanar views of the deformed spine (as well as of the appendicular skeleton if needed). EOS will become more widely available in time but is nowadays an expensive tool that many centers cannot afford. Nevertheless, even in the absence of EOS surgeons should make every effort to obtain high quality full spine standing AP and lateral X-rays including the hips and 10 cm of the femurs along with flexed elbows in order to study the proximal thoracic tract. Once adequate imaging is obtained, the planning of corrective osteotomies can take place. Accepted techniques are wedge, pedicular and vertebral column resection osteotomies. These are all performed by a posterior approach and rely on solid pedicle instrumentation - two to three levels above and below - to obtain immediate corrective power, unfortunately at the expense of significant morbidity[5,11]. Major complications including death, permanent paralysis, pseudoarthrosis, proximal junctional failure and infection may affect up to 60% of treated patients and are largely dependent on age, degree of sagittal imbalance and medical comorbidities at the current state of knowledge[3-6,11]. In addition, there seems to be wide variability in revision rates among centers treating different volumes of patients[12]. Hence, the role of minimally invasive anterior (and posterior) support in ASD surgery is increasingly reported[7,8] and its efficacy awaits the test of time.

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