The ancient “apples and oranges” conundrum: a call for methodological precision

TO THE EDITOR: In a recently published article, Gillis et al. proposed to analyze the improvement in several radiographic parameters in patients submitted to 1- and 2-level anterior cervical discectomy (ACDF) with lorderotic cages through measurements performed on lateral radiographic images at 3 time points: preoperatively, at 6 weeks, and at 1 year postoperatively (Gillis CC, Kaszuba MC, Traynelis VC: Cervical radiographic parameters in 1- and 2-level anterior cervical discectomy and fusion. J Neurosurg Spine 25:421–429, October 2016).

In such a study, although accuracy may not be a key concern (as radiographs obtained with 10° of neck extension may be interpreted as neutral if all further measurements are performed on similar radiographs with 10° of extension), precision (i.e., the consistency between different measurements) is of paramount importance in order to avoid comparisons between images that are simply not comparable.

Although the article presents an extensive description of the obtained radiographic measurements, a simple analysis of Figs. 1 and 2 generates serious questions about the methodological quality of the performed measurements, especially regarding their precision. For instance, Fig 1A and B, which are clearly not perfect lateral radiographs (as it can be noted by the double shadow of the facet joints, arrows in Fig. 1B), are compared with a perfect lateral radiograph (Fig. 1C, properly overlapping facets). More concerning than that is the fact that, while Fig. 1A seems to be a neutral radiograph, Fig. 1B already demonstrates some degree of cervical extension, which becomes much more pronounced in Fig. 1C (a measured difference of 9° between Fig. 1A and 1C). This discrepancy becomes even

FIG. 1. Reprint of Fig. 1 from the article, with the black lines and degree measurements and the white arrows added to originals. The angle between C-1 and the superior endplate of C-5 was measured on the preoperative image as well as at the 1-year follow-up (note that the same lines used by the authors were used in order to avoid even minimal discrepancies in the measurements). There is a change from 28° to 37° at the angle of C1–5 between the preoperative and postoperative images, confirming that the postoperative radiograph was obtained 9° in extension in relation to the preoperative radiograph. Also note that the mandible/bite line is also not parallel to the ground in panel A, as it is in panel C. Please also note the double shadow of the facet joints in panels A and B (white arrows), confirming that the radiograph is not a perfect lateral as it is in panel C. Modified from Gillis et al.: J Neurosurg Spine 25:421–429, 2016, with permission. Figure is available in color online only.
It is important to highlight that, in patients with significant cervical kyphosis, it has already been demonstrated that neck extension by itself has a limited effect in terms of its ability to change the sagittal balance, usually being insufficient to reverse the cervical kyphosis to a physiological lordosis. However, this is clearly not the case of the patients analyzed in the study by Gillis et al., all of whom presented with preoperative C1–7 lordosis greater than 40° according to Table 2 of the original article. In such a group of patients, classic biomechanical studies have already demonstrated that each healthy level in the subaxial cervical spine may demonstrate a range of motion of up to 10° between flexion and extension.

The authors could possibly argue that all radiographs were obtained in a naturally neutral position, which would theoretically represent the patient’s rest position. In such a scenario, the increase in the overall cervical lordosis after the ACDF could be attributed, for example, to a reduction in the cervical muscle spasms, ultimately reflecting an improvement in the cervical biomechanics. However, it is quite questionable that patients with only 1 or 2 levels affected by spondylotic changes would present with such a narrow comfort zone that would enable precise estimation of the effects of ACDF on their cervical biomechanics. Ultimately, if there is not a strict protocol to obtain standard neutral radiographs (for example, by aligning the mandible/bite line with the horizontal plane), it is very likely that the specific degree of cervical extension in each radiograph (and, therefore, most of the values in Table 2 in the article) was ultimately determined by each patient’s random choice in their self-positioning within a wide range deemed to be within such a “comfort zone,” or, more likely, by the gross estimation of the x-ray technologist who positioned the patient’s head in what he or she believed to be a roughly neutral position.

This “apples and oranges” comparison effect becomes even clearer in Fig. 2. Besides from artificial changes in the degree of neck extension (as revealed by the different relationship of the mandible/bite line from Fig. 2A to 2C), how would it be possible, aside from an artificial effect secondary to neck extension, for the overall cervical lordosis to improve from 5.4° at 6 weeks to 17.4° at 1 year if the improvement in the segmental lordosis at the operated levels decreased from 10.3° at 6 weeks to 7.2° by 1 year (likely due to small subsidence of the allograft)?

If such methodological concerns affected not only the measurements performed in Figs. 1 and 2 but actually every radiographic evaluation, all values described in Table 2 regarding C2–7 lordosis, C1–7 lordosis, T-1 slope, and C2–7 sagittal vertical axis may simply be unreliable, ultimately rendering any further statistical analysis performed on such values devoid of any meaningful clinical implications.

Ultimately, the only values that can be expected to be unchanged even when using radiographs with different degrees of neck extension are those of focal lordosis and disc height. However, after a careful analysis, even these values become amenable to criticism. It is hard, for example, to explain how 6° lordotic allografts used in a 1-level ACDF would lead to only an average of 3.92° of improvement in the focal lordosis at 6 weeks (Table 2).