The role of smartphone technology in trauma spine surgery

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Stahl *et al.* (1) have published a very interesting paper on the reliability of smartphone video message to evaluate spinal thoracolumbar fractures and assist remote decision-making. Although research is just starting on this field of medicine, without a doubt clinicians are already using their own smartphones to capture, record and send image files for research and clinical purposes. We read in Stahl's study that between 72% and 84% of physicians in the United States routinely use their personal smartphones for professional activities. In a study run in Germany in the year 2014 (2), authors reported that 23.6% of neurosurgical departments in their country use smartphone screenshots of computed tomography (CT) images transmitted by multimedia messaging service. However, from the 47% of neurosurgeons who reported owning a smartphone, only 1.1% used their phone for on-call image communication. In the last years that number has necessarily increased. Stahl's study (1) is a good evidence that images can be examined with the same precision if they come from a desktop computer work station or if they come from a smaller smartphone screen that can be kept in a pocket. Technology is advancing quickly and people are keeping the path of its advantages. "Mobile health" has promising potential in improving healthcare delivery, not only in personal or individual healthcare as we can see in different recent sport-health related apps, but also in the field of technical medicine by facilitating access to expert analysis and advice. In our professional system, enabling on-call specialists to review images on their smartphones and make accurate diagnosis may save time, enable a better communication between colleges (for example attending-residents), and improve the transfer of a patient between hospitals and a tertiary trauma center (1).

Some studies have reported successful outcomes when assessing whether images viewed by specialists on smartphones and tablets are of comparable quality as when viewed on a computer screen in emergency settings (3). Image analysis on handheld devices allow highly accurate interpretations in a variety of clinical applications, including: chest radiographs for pneumothorax; chest CT for lung nodules; and CT for acute stroke (4); angiographic lesions via the FaceTime application (5); diagnosis of neonatal pneumothorax (6); evaluation of acute appendicitis (7); and applications in different orthopaedic fields like pediatric trauma or tibial fractures (1).

The conclusions that we read in Stahl's paper (1) are that smartphone screens enable surgeons to examine thoracolumbar fracture images, accurate diagnose and classify those fractures and make decisions in a similar way that in the clinical setting. Several items were analyzed in that study, and in my opinion some of them are quite difficult to assess by just looking at a smartphone screen. Calculating neural canal penetration, loss of vertebral height or degrees of segmental kyphosis needs measuring tools that are available on desktop computers, but not yet in smartphone devices. Recognized as a limitation by the authors, this may answer why the Kappa (k) score for kyphosis was just 0.45, and for loss of vertebral height was k=0.55. We even have trouble to properly measure loss of height in those fractures that have undergone asymmetric compression, as one part of the vertebral body may show different loss of height than another, making calculations difficult to perform. The same happens with canal encroachment.

Regarding fracture classification, even on big screens and scroll available images, agreement is still today suboptimal. Vertebral fracture patterns of AO classification have been historically established via X-ray and CT analysis, achieving modest reproducibility values. The classic AO classification (8) describes three basic fracture types according to lesion primary mechanism (A) compression, (B) distraction (involving PLC injury) and (C) rotation (involving PLC injury and vertebral body translation). Likewise these are divided into three subgroups, each with three subdivisions. Some authors claimed the subdivision complexity is the reason for low reproducibility indices. Wood *et al.* (9) published an agreement among 19 spine surgery fellows of k=0.48 using X-ray and CT; while Oner *et al.* (10) obtained a kappa value of 0.35, combining surgeons, radiologists and residents. An improved AO classification came out in 2013 subdividing A3 type fractures into A3 (incomplete burst) and A4 (complete burst), and modifying type C patterns (11). Despite this effort to improve classification description and interpretation accuracy, the most controversial point stays unresolved. This is the differentiation of the most stable patterns (type A) from the most complex or unstable ones (types B or C). Biomechanically the main difference lies in the condition of the posterior ligamentous complex (PLC). If the complex is not damaged, the fracture is considered type A, while if the complex is injured or disrupted it becomes a type B or C. With the classic evaluation tools (X-ray and CT images) the PLC is still difficult to assess, only indirect signs can lead us to suspect an injured complex (12). MRI is the imaging tool that can more accurately diagnose the stability of the posterior complex. When MRI was used to identify PLC rupture and classify fracture pattern by Magerl's classification, we were able to differentiate these three main categories with moderate but improved interobserver values (k=0.53) (13), improving the reliability of previous authors (9,10). We were also able to show in that study, that the greater the observer's experience with the AO classification, the better the agreement, with more uniform results. Senior observers obtained the maximum interobserver agreement (k=0.59) while residents obtained a lower one (k=0.45). We also demonstrated a greater interobserver reliability among the spinal surgeons' group (k=0.71), compared to the radiologists' subgroup (k=0.48). We concluded that the feedback obtained from surgery teaches the surgeon to better assess PLC imaging. In another study (14), we reported that the use of MRI in spinal thoracolumbar trauma modified our diagnosis in 40% of our patients (discovering 18 occult injuries), modified the classification fracture pattern in 24% of our fractures (mostly upgrading type A to type B patterns), and modified the therapeutic management in 16% of our patients. We resolved that MRI was a useful tool in the evaluation of thoracolumbar acute fractures as it allowed a better visualization of the posterior complex integrity and of the levels involved, offering additional information compared to traditional diagnostic tools (X-rays and CT). However, PLC diagnosis not only relays on the imaging tool that is used, it needs a criteria to differentiate when the complex is disrupted. In many centers, an edema of the interspinous ligament is still interpreted as a posterior complex instability, pushing decision making into the surgical option. That is why we analyzed PLC images and compared them to what happened anatomically, and came up with a "dicothomic" stability criterion. The PLC has a biomechanical sequence of rupture (15), and only when the sequence reaches the supraspinous ligament rupture, then can the complex be considered unstable (16). When with this criteria and using MRI, the AO classification is evaluated, accuracy in PLC injury diagnosis increases both in isolated component analysis and PLC as a whole, achieving a sensitivity and specificity of 91% and 100% respectively (17). These concepts are expressed also to highlight that a future project could be establishing if smartphone MRI images compare to CT images when classifying spine fractures.

In 2013, the new AO classification proposed by Reinhold (11) was modified to form the AOSpine thoracolumbar spine injury classification (18). Urrutia *et al.* have already reported the reliability of this new classification (19). Although some subtypes were modified to easy fracture interpretation (mainly simplifying C types), the interobserver reliability is still far from being perfect. When considering the fracture type (A, B, or C) the reliability was κ=0.62, which is very similar to that reported by the group that developed the new classification (20). The interobserver agreement when considering the subtypes was moderate (κ=0.55). The intraobserver reproducibility was 85.95% considering the fracture type (with κ=0.77), and 75.71% when considering subtypes (κ=0.71). Bearing in mind these published data, it is amazing to see that Stahl (1) reported a nearly perfect (k=0.94) intraobserver agreement for AO classification with kappa values as high as 0.75 using smartphone teleinterpretation. I can't answer the reason of such high agreement; it might be related to a limitation stated in the manuscript: the surgeons participating in the survey had treated these patients previously in the past year.

Some operated cases are deeply studied before surgery, so certain images could have been familiar to those observers involved in the cases, thus recalling the images could have biased the results. But it could also be that specialists participating in the study were highly accurate with fracture classification.

To conclude, spine fracture classifications have been evolving to ease subtypes and achieve a better reliability among observers. However reproducibility is still not perfect. MRI can help defining fracture pattern and specially PLC stability, and it is a good aid to X-rays and CT images. Smartphone video message technology has significant potential for facilitating early diagnosis and timely access to treatment in the context of spinal trauma. Further studies validating the different of options offered by emerging mobile health technologies will increase its value as an adjunct to clinical decision making.

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