Learning curve analysis of minimally invasive total knee arthroplasty using segmented linear regression modelling

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DEAR EDITOR,

We recently read the article by Cheng et al entitled "Analysis of learning curve of minimally invasive total knee arthroplasty: A single surgeon's experience with 4017 cases over a nine-years period" with great interest.[1] The authors undertook a long-term learning curve analysis of minimally-invasive total knee arthroplasty (MIS-TKA) on over 4000 cases using several learning outcome measures including tourniquet time, complications, radiographic data, and patient-reported outcome measures. In recent years, several studies investigating the learning curve of surgical procedures have employed the group-splitting technique, which is, however, fraught with bias.[2] Cheng et al used continuous data modelling, which is a superior method for learning curve analysis, and certainly overcomes limitations of the group-splitting technique.

We note that they assumed the learning curve of all variables will be best defined by a single straight line with equation y = mx + c. However, the typical learning curve demonstrates a negative exponential relationship, based on the theory of deliberate practice.[3] Indeed, high-order functions to model learning complicate interpretation. Segmented linear regression techniques allow a greater amount of complexity to be identified, and a more accurate description of learning to be obtained that is simple, quantitative, and intuitive.[4] It is surprising for all outcome measures of learning collected over a 9-year period for over 4000 MIS-TKAs to demonstrate constant learning without any evidence of a plateau or a change in the rate of learning. A study looking at the learning curve of navigated total knee replacements found that operative time reached a plateau after 26 cases.[4] Indeed, Cheng et al's graph of complications visually appears to possibly attain a plateau after ten 3-month periods, and knee alignment appears to possibly attain a plateau after fifteen 3-month intervals. The graph of tourniquet time indeed does not visually appear to attain a plateau, but this can only be confirmed by employing a segmented regression technique that compares different models of increasing complexity.

Should segmented linear regression reveal that tourniquet time improves at a constant rate, with no change in rate of learning after 4000 cases, this would suggest that the procedure is extremely difficult to learn and only high-volume surgeons who employ this technique on a regular basis should attempt to introduce it. Surgeons may be reassured, however, that patient-reported outcome measures, radiographic alignment, and complications may reach a plateau much sooner.

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