Response

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We thank Dr. Forrest for his comprehensive and thoughtful review of our paper. As correctly pointed out, this work primarily focuses on spring biomechanics: another publication from our group, reporting clinical data and clinical outcomes, forms the body of a separate paper currently in press.

Dr. Forrest has correctly reported that springs have been used at our institution since January 2008: to date, about 300 cases utilizing more than 750 springs have been performed. A number of clinical studies in the literature (also from our unit) support a particular technique with limited case experience and follow-up periods. We have, with some difficulty, resisted this temptation and withheld publishing our experience until we felt comfortable with the evidence we are presenting. We can confirm that the morbidity profile of this patient cohort compares rather favorably with our own historic cohorts and with the currently "accepted" profile for a large craniofacial practice within the literature. The figures are large enough and speak for themselves.

Outcome analysis remains difficult across the spectrum of craniofacial interventions and the correction of scaphocephaly is no exception. While it is clear that this procedure enables the majority of our patients to pass the "supermarket test" (in our departmental audits, over 90% of parents score the aesthetic results of these procedures as an 8 or more out of 10, with 10 being maximum satisfaction), we can confidently state that this technique does not work well enough in all patients. It is excellent at treating the occipital bullet and posterior vertex height and good at addressing biparietal widening, but is limited at treating the frontal bossing and pterional pinching. So, for a child who presents at an early age (3 months) with significant frontal bossing, we would not expect an optimal result. Following discussion with the parents, we may still advocate proceeding, with the expectation that frontoorbital remodeling may be required at a later stage instead of a total calvarial remodeling. This matter is analyzed further in the clinical outcomes paper. For our unit, the biggest advantage is the minimal nature of the intervention with its single-digit transfusion rate and overnight stay in a regular hospital bed.

The thrust of our paper remains the spring kinematics in this patient cohort, and while studies in the literature report spring outcomes in animal models and in clinical cohorts, the non-standardized nature of the springs and wire forms used across various centers makes the biomechanics studies difficult. By employing a standardized design in a stereotypical fashion over 9 years, we have been able to analyze the viscoelastic properties of the pediatric calvarium and the changes obtained by applying force vectors on it. As our understanding of the biomechanics increases, it will be possible to formulate guidelines to aid the surgeon new to the technique and help with informed consent. Computer modeling techniques such as finite-element modeling and statistical shape modeling are likely to increase the predictability of spring cranioplasty and allow for surgical planning.

We share with Dr. Forrest the opinion that the best operation for these children is no operation if the results can be achieved by other noninvasive means or, until such a technique becomes available, by one that has the most favorable intervention/outcome ratio. Within our practice, the spring-assisted procedure outperforms other techniques according to this criterion.