

Learning Curve Analysis of Autologous Skin Cell Suspension Used for the Closure of Full-Thickness Wounds: Outcomes of the First 100 Consecutive Patients Treated with “Spray-on Skin” at an Urban, Level-1 Trauma Center



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Purpose

Autologous Skin Cell Suspension (ASCS), or “spray-on skin,” has documented efficacy in closing full-thickness wounds, but concern has been raised regarding potentially increased operative times and excess resource utilization. This study aimed to evaluate the clinical outcomes and procedural efficiency of ASCS in the treatment of full-thickness wounds at a high-volume, urban level-1 trauma center.

Specifically, we aimed to assess the learning curve associated with ASCS application using the cumulative sum (CUSUM) method to define operative competency and mastery over time. In doing so, we sought to determine the impact of experience on operative duration, complication rates, and resource utilization, while identifying potential predictors of prolonged operative times in the early adoption phase of this novel wound closure technique.

Methods

100 consecutive patients with full-thickness wounds were treated with the bilayer technique of 3:1 widely-meshed, thin autograft and 80:1 expanded ASCS. Single-cell suspension of keratinocytes, melanocytes, and fibroblasts underwent intra-operative, point-of-care preparation prior to aerosolization. Learning curves were assessed by the cumulative sum (CUSUM) method of operative times, with competency defined as initial peak of the CUSUM graph and mastery by the final decline of the learning curve.

Results

Wound closure was achieved in 76%, 95%, and 98% of patients at 4, 8, and 12 weeks (Figure 1). Limb salvage occurred in 81/82 patients with extremity defects (Figure 2). Regarding operative times, competency was achieved by the 23rd case, and mastery occurred by the 66th case (Figure 3). Mean operative time decreased from 132 to 108 minutes from the competency phase to the mastery phase ($p=0.01$). Complications decreased slightly from 30% to 24% (NS), whereas length of stay remained the same at 3 weeks. The only predictor of prolonged operative times was increased wound size (Figure 4).

Results

Figure 1. Wound Closure. This graph displays the wound closure rates by 4, 8, and 12 weeks within our patient population.

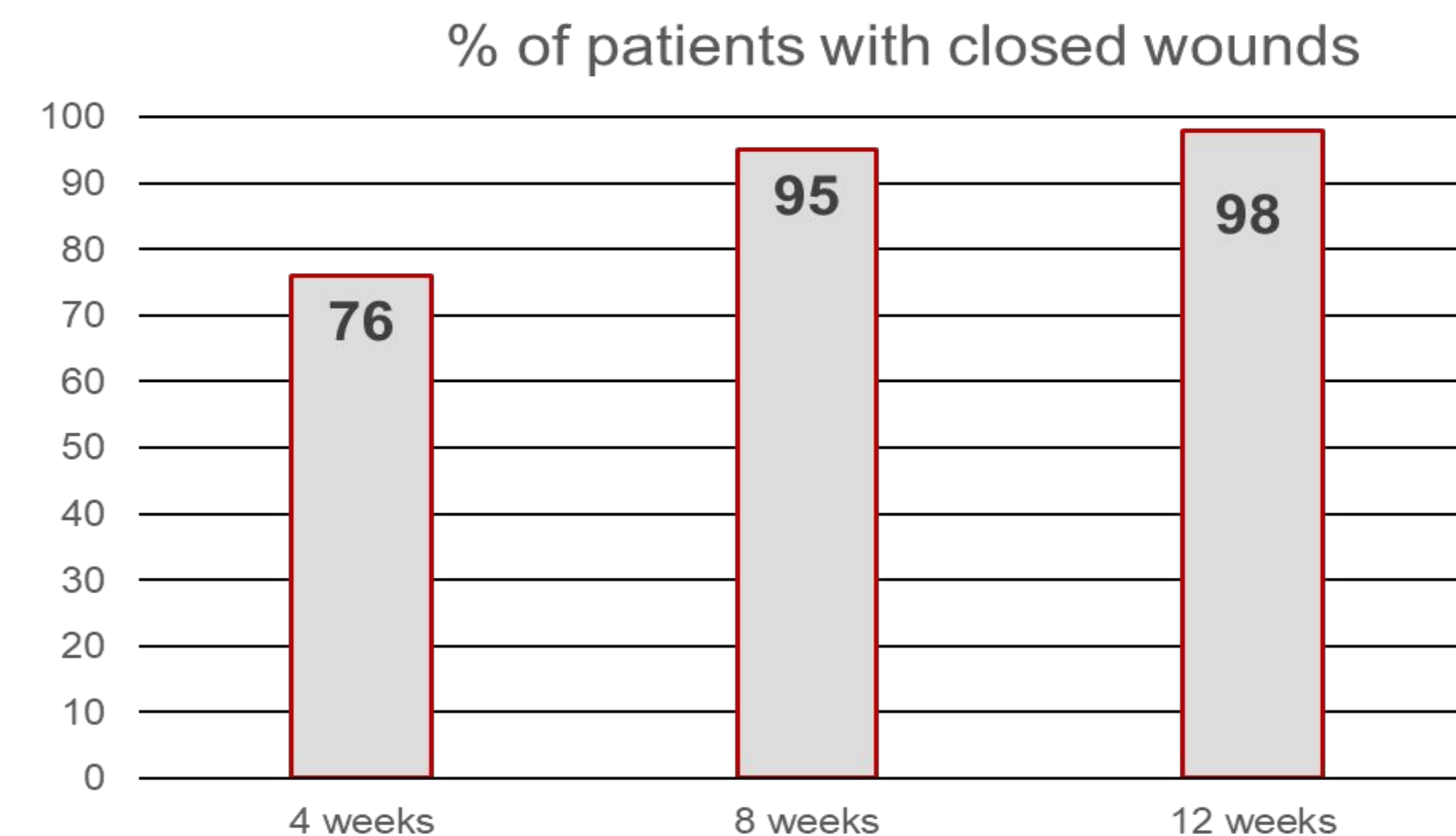


Figure 2. 66 year old woman with golf cart crush right tibial fracture and soft tissue degloving treated with piscine xenograft and 3:1 split-thickness skin graft with ASCS, at initial evaluation, early post-operation, and long-term follow up, respectively.



Figure 3. CUSUM Learning Curves. Competency was found at case 23, while mastery was found at case 66.

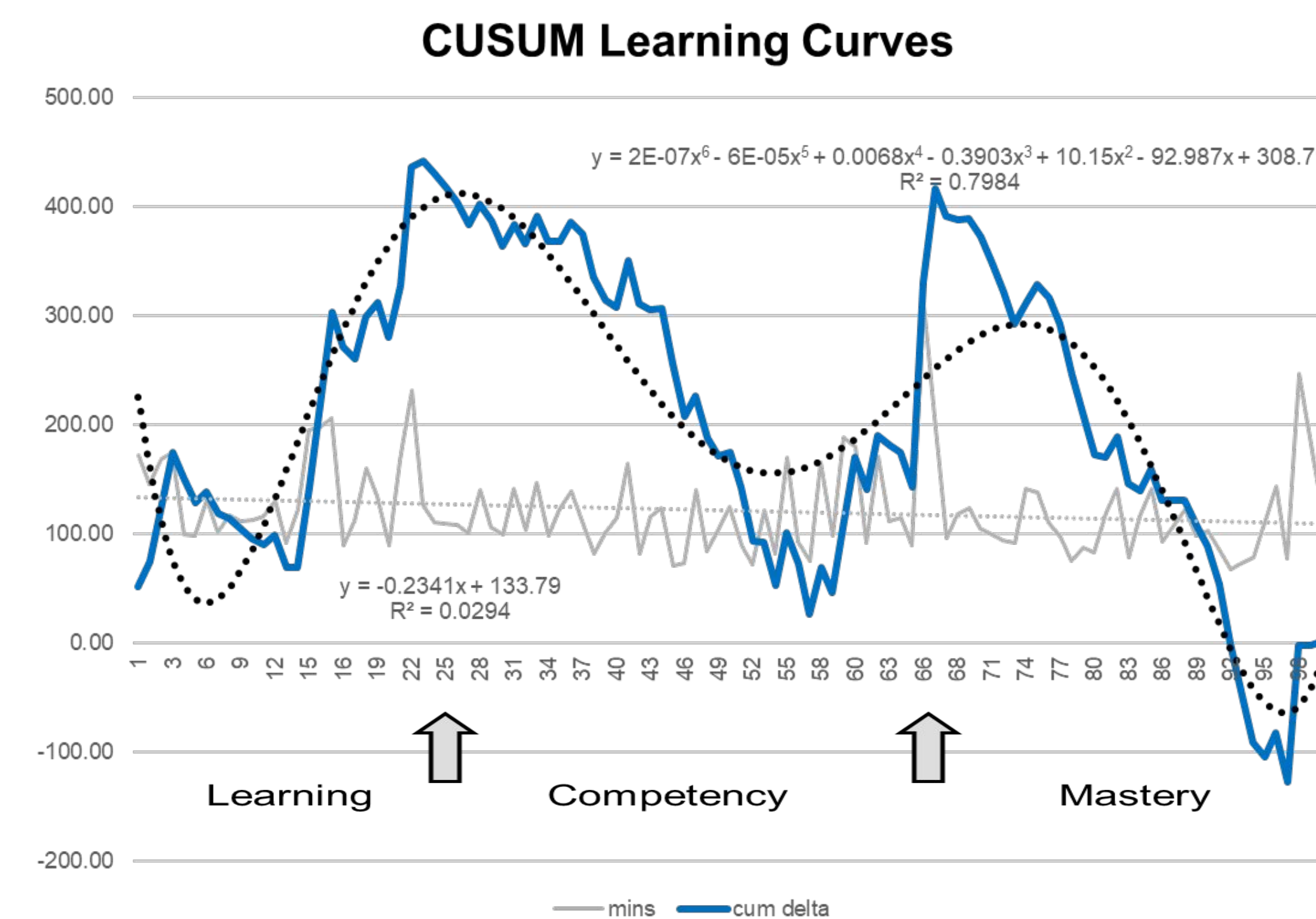
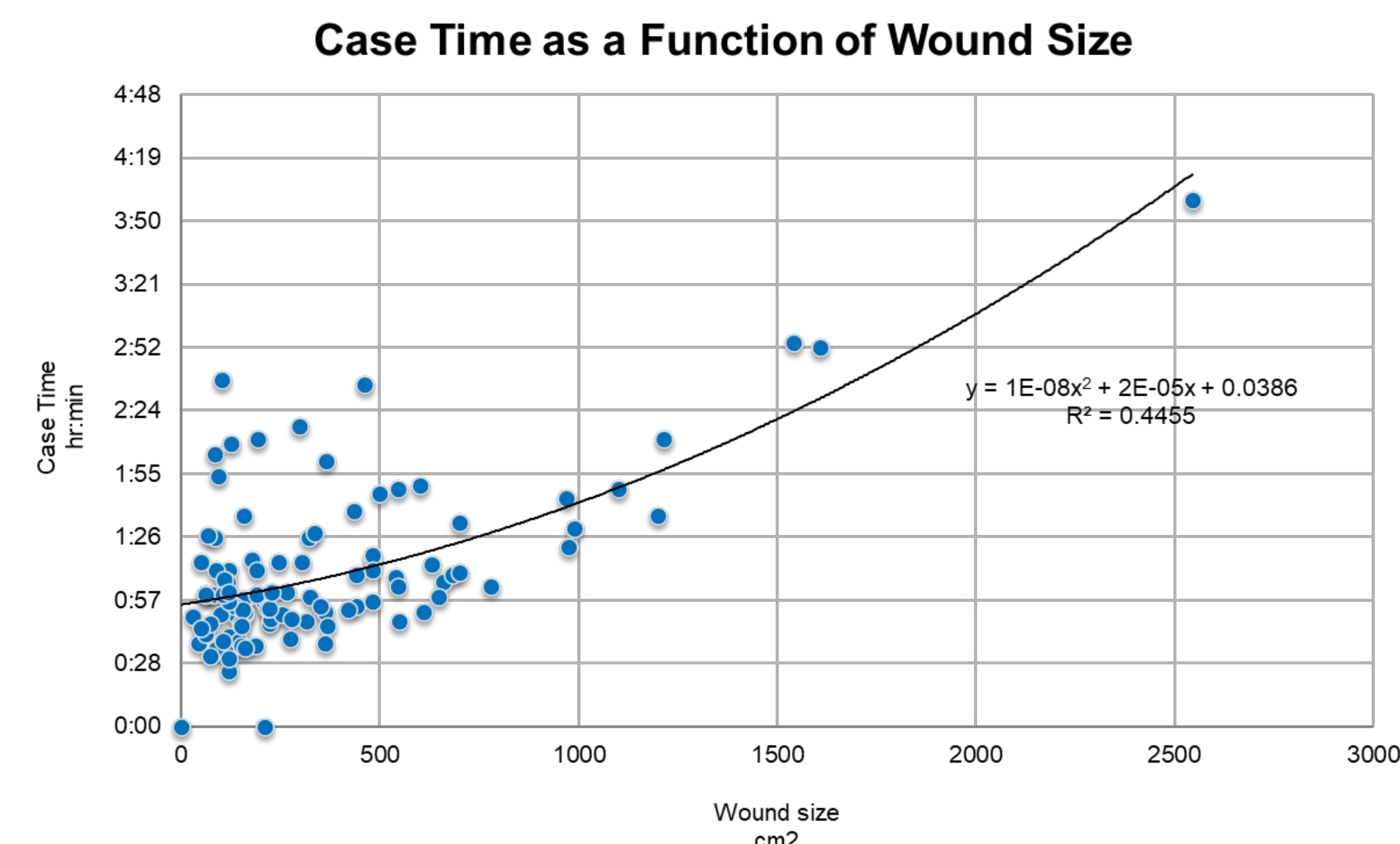


Figure 4. Case time plotted against wound size.



Discussion

The learning curve analysis provides novel insight into the successful operative adoption of ASCS. Using cumulative sum (CUSUM) methodology, we found that surgical competency was achieved relatively early, by the 23rd case, while mastery was not reached until the 66th case. This two-phase progression—initial technical proficiency followed by optimization of efficiency—has important implications for training, resource planning, and quality benchmarking in institutions incorporating ASCS into their reconstructive algorithms. The significant reduction in mean operative time from 132 to 108 minutes across these phases ($p = 0.01$) supports the presence of a measurable learning effect.

While complication rates declined slightly over time, the difference was not statistically significant, possibly reflecting the complexity of patient comorbidities and wound characteristics. Importantly, the only independent predictor of prolonged operative times was increased wound size, highlighting the need for careful operative planning in patients with large or multifocal defects.

Overall, these findings validate ASCS as a reliable and scalable modality for complex wound reconstruction, with a learning curve that can be overcome relatively quickly in experienced surgical hands. Further research should investigate the long-term durability of ASCS-based reconstruction and the cost-effectiveness of its widespread adoption across different clinical environments.

Conclusion

ASCS is an effective, reliable, and time-efficient method for closure of full-thickness wounds and defects. Regarding operative times and learning curves for ASCS, competency can be achieved relatively quickly, but mastery may take longer than expected.

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