Published in final edited form as:

Plast Reconstr Surg. 2017 March ; 139(3): 672–680. doi:10.1097/PRS.0000000000003087.

Annual Hospital Volume and Success of Digital Replantation

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Abstract

Objective—Digital replantation attempt and success rates have been declining in the U.S. Regionalization of digit replantation has been proposed as a solution to improve both attempt and success rates of these procedures. There is limited information about which criteria could establish a hospital as a center specialized for digit replantation. We analyzed hospital replantation volume and patient factors associated with successful thumb/finger replantation.

Methods—A retrospective study using data from 2008–2012 State Inpatient Data (SID) of Health Care Cost and Utilization project (HCUP) from five states (New York, California, North Carolina, Utah, and Florida) was performed. Generalized Estimating Equation (GEE) method was used to examine the association between patient characteristics and hospital volume and success of thumb/finger replantation. A Receiver Operating Characteristic (ROC) curve and Youden's J statistic were used to determine annual hospital replant volume cut-off levels for success rates.

Results—There were 3,417 digit amputation injuries, with 631 replant attempts (18%) with an overall thumb/finger replantation success rate of 70%. The hospital annual replantation volume increased the odds of success (OR=1.06, CI: 1.02–1.10). The annual hospital volume of 3 replants was needed to achieve a success rate of 70%.

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Disclosures:

Matthew Brown has no commercial or financial conflict of interests to report.

Yiwen Lu has no commercial or financial conflict of interests to report.

Elham Mahmoudi has no commercial or financial conflict of interests to report.

Kevin Chung has no commercial or financial conflict of interests to report.

Author Contributions

Dr. Matthew Brown was involved in the study design, data analysis and manuscript preparation

Yiwen Lu was involved in the study design, data acquisition, statistical analysis, and manuscript preparation

Dr. Kevin Chung was involved in the study conception and manuscript review

Dr. Elham Mahmoudi was involved in study conception, design, data analysis, manuscript preparation and review.

Supplemental Digital Content 1, Appendix A1 Diagnose and Procedure Codes for Digit Amputation Injuries, Digit Replantation and Debridement. Appendix A2. Comorbidities List for "Number of Comorbidities Variable" in the GEE Model.

Conclusions—Practice patterns demonstrate that hospitals with higher annual volume have greater success. Identifying high-volume centers and regionalization of digit replantation should be considered a priority.

Keywords

Thumb/Finger; Amputation; Replantation; Injury; HCUP

Introduction

Since the first report of a thumb replantation in 1968 by Komatsu and Tamai, reattachment of amputated digits has been performed with a relatively high success rate all over the world.^{1,2} Digit replantation is a complex operation that requires adequate expertise in microsurgical techniques and a strong background in hand surgery. Over the last couple of decades, there is evidence that the prevalence and success of digit replantation in the United States has been steadily decreasing.^{3–5} Declining trends in digit replantation have been linked to rising health care costs, scarcity and maldistribution of hand surgeons with microsurgical skills, low reimbursement rates for digit replantation, and unavailability of on-call hand surgeons in many hospitals.^{5–7}

Surgical case volume for digit replantation has been associated with improved outcomes indicating that surgeons who perform replantation are more proficient.^{5,8} Recently, the decentralization of digit replantation has been implicated as one factor contributing to the decreased prevalence and success of the procedure.⁵ This study demonstrated that a shift in amputation cases from traditionally higher volume centers and surgeons to lower volume hospitals and surgeons has led to a decrease in both the rate and success of replantation at all institutions. Regionalization of care was shown to be effective in improving health outcomes after various traumatic injuries; however, the trauma system is not structured specifically to extremity injuries such as digit amputation.^{9–11} Chung et al determined that only 15% of hospitals in the U.S. perform replant, and of those only 2% perform 10 or more per year.⁶ Peterson et al performed a survey study of Level I and Level II trauma centers and found that the availability of replant services was not consistent.¹² They demonstrated that 55% of Level 1 and 29% of level 2 had immediate access to microvascular services on a daily basis, whereas other hospitals had inconsistent access or no coverage for replant services at all. Currently, there are no specific criteria defining a specialized center for digit replantation or a minimum volume a hospital needs to maintain to maintain expertise in this area.

Using the 2008–2012 State Inpatient Data (SID) of Health Care Cost and Utilization project (HCUP) from New York, California, Utah, North Carolina, and Florida, our specific aims were to: (1) identify patient related factors attributed to success or failure of thumb/finger replantation, (2) evaluate attempt and success rate of digital replantation over the study time period (3) determine volume-outcome association in success of a replanted thumb/finger. We hypothesized that hospitals with a higher volume of replant procedure had higher odds of successful thumb/finger replant.

Methods

Data Source

We performed a retrospective study using data from SID from five states with 3 to 5 years of data: California (2008–2011), North Carolina (2008–2010), Utah (2008–2011), Florida (2008–2012) and New York (2008–2012).¹³ The Agency for Healthcare Research and Quality manages the Healthcare Cost and Utilization Project (HCUP).¹⁴ Each database includes hospital discharge records for all patients with a unique patient identifier and hospital identifier, so patients can be followed over time within a one-year period.

Furthermore, we collected additional hospital information from the 2012 American Hospital Association (AHA) Annual Survey Database¹⁵; we used the unique hospital identifier from the HCUP SID data to link the HCUP data files with the AHA file.

Patient Selection

We included all patients who had digit amputation and underwent either revision amputation or single replantation during the follow-up period in five states. Targeted patients were identified by the use of *International Classification of Disease, Ninth Revision, Clinical Modification* diagnose codes, 885.0, 885.1, 886.0 and 886.1 (simple or complex thumb/finger amputation), and *International Classification of Disease, Ninth Revision, or Clinical Modification* procedure codes, 84.21, 84.02, 84.22 and 84.01 (replantation, or revision amputation) (See Appendix A1, Supplemental Digital Content 1, which shows the Diagnose and Procedure codes for Digit Amputation Injuries, Digital Replantation and Debridement, INSERT LINK). To be included in our final sample, patients must have at least one ICD-9-CM diagnose code and at least one ICD-9-CM procedure code. HCUP databases use VISITLINK as a unique record identifier for each patient. Patients without a unique identifier could not be followed over a one-year period and were excluded from our final sample. The VISITLINK variable was missing from North Carolina (NC) database between 2011 and 2012. Thus we were not able to include the 2011–2012 data from NC in our final sample. A hospital identifier was needed for merging HCUP data with American Hospital Association Annual Survey Database (AHA). Four observations without a hospital identifier were excluded. Finally, we excluded individuals younger than 18 years of age from our final sample to focus the study on the adult population. Figure 1 shows the schematic flow of our sample selection. We used ICD-9-CM codes, listed in the Appendix A1 (Supplemental Digital Content 1), to identify a total of 3,417 patients, 18 years of age or older, with digit amputation injuries. A total of 631 patients underwent replantation and 515 had complete observations for our model. A digit replantation was considered successful if no revision amputation or debridement was performed within two weeks after replantation procedure. To define the result of every episode of digit replantation, we measured attempted digit replantation episodes when both ICD-9 diagnosis codes for digit amputation and ICD-9 procedure codes for digit replantation for the same patient exist in the database. Using the ICD-9-CM coding system, one cannot determine which finger was amputated and whether the injured digit is on the right or left hand.

Statistical Analysis

We examined the association between hospital annual volume and result of digit replantation, adjusting for patient and hospital characteristics. We used Generalized Estimating Equation (GEE) approach to examine the association between patient and hospital characteristics and success of digit replantation surgery after traumatic amputation.¹⁶ We adjusted for repeated measures within each hospital by putting the hospital identifier variable after the REPEATED statement for GENMOD procedure in SAS. We used a logit link function to model success of digit replantation. Hospital characteristic included hospital annual digit replantation volume. Patient characteristics included age, number of comorbidities, gender, type of insurance, race, median household income, and length of stay in hospital.

We estimated the optimal cutoff value for the annual replantation volume at a hospital level by drawing the Receiver Operating Characteristic (ROC) curve and calculating Youden's J statistic. The area under the ROC curve (AUC) is a measure of the overall performance of a diagnostic test, which reflects the overall performance of the model. It ranges from 0.5 to 1. If AUC value is 0.5, the discrimination between the success and failure will depend on pure chance instead of variables in the model. The higher the AUC value is, the better the overall diagnostic performance of the test is. To draw the ROC curve for our model, we used the same variables as we did in the GEE model. We aimed to determine the optimal cutoff value for the annual replantation volume, adjusting for other variables in our regression model. We used the maximum value Youden's J statistics, a common criterion for obtaining the optimal cutoff value of a continuous variable, to estimate the optimal cutoff point of annual hospital volume for the predicted success rate.¹⁷ Detailed steps in SAS are shown in the Appendix (Supplemental Digital Content 1). The data analysis for this paper was generated using SAS 9.3 (Copyright © SAS Institute Inc, Cary, NC, USA.).

Results

Table 1 shows the characteristics of patients with attempted digit replantation. Out of 515 patients who underwent replantation, 358 or 70% had successful replantation. Analysis of payer type revealed significant differences between patients with successful and patients with failed replantation ($P=0.001$). About 32% of patients with private payer compared with 12% of patients with no insurance had a successful replantation. Patients with a successful replantation had an average hospital stay of 5 days compared with 6 days for those with failed replantation ($P=0.009$).

Table 2 shows the results of the regression analysis, adjusting for patient mix. Patients with Medicare and Medicaid had higher odds of having successful replantation compared with private insurance (OR=3.54; CI: 1.24–10.16 and OR=2.14; CI=1.10–4.15, respectively). Patients with no charge or other type of payer compared with those with private payer had lower odds of success (OR=0.58; CI: 0.37–0.92). Finally, hospitals with a higher annual digit replantation volume had greater odds of performing successful replantation (OR: 1.06; CI: 1.02–1.10).

Figure 2 shows unadjusted attempt and success rates for digit amputation injuries, clustered by hospital digit replantation volume. Hospitals that had fewer than two annual digit replantations (low-volume) attempted to replant 11% of digit amputation injuries with 68% success rate. On the other hand, hospitals that had five or more annual digit replantations (high-volume) attempted to replant 31% of digit amputation injuries with 75% success rate.

Figure 3 shows the estimated ROC curve based on continuous number of annual replantation at each hospital. The AUC value was 0.69, which suggests an acceptable overall performance of the model. The best cutoff corresponding to the highest Youden's J statistic was hospitals with at least 3 annual replantation cases. At this point, the success rate for digit replantation was 70%. Additionally, our sample indicates that to achieve an 80–90% success rate, hospitals should perform a minimum of 17 digit replantation cases annually.

Discussion

In this study, we used state-level HCUP data from five states to examine the influence of patient factors and hospital volume on thumb and finger replantation success. The overall rate of success was 70% over the study period, which is consistent with previously published studies.^{4,5,18–20} Patient demographic characteristics did not contribute to success or failure although payer type showed some significant differences. Hospitals that performed a greater number of annual replants achieved a higher success and successful replants were associated with a shorter length of stay. Lastly, we were able to calculate the annual volume of replants necessary to achieve 67% and 80% success rate using an ROC curve which is unique to this study.

The success or failure of digit replantation has been considered highly dependent on intra-operative decision and technical proficiency, but also affected substantially by the mechanism of injury.^{8,21–23} Similar to our findings, non-surgical patient factors have not been shown to have significant influence on success.¹⁹ Our study revealed payer type affected the outcomes of replantation. Interestingly, those with Medicaid and Medicare had improved odds for success in comparison to those with private payer. Prior work has established that patients with no insurance or undesirable insurance are more likely to be transferred to higher-volume trauma centers compared with patients who have private insurance.^{24–26} Our data show a slightly higher percentage of patients with Medicaid and Medicare in high-volume hospitals compared with low-volume hospitals (10% vs. 8% - but not statistically significant). It may be that the higher success in this population is secondary to the fact that Medicaid patients were being transferred to higher volume replantation hospitals. Previous studies have also demonstrated the influence of smoking and certain comorbidities on replant success.^{18,21,22,27,28} Our study evaluated the number of comorbidities and did not find association with replant success or failure. Overall the relative lack of influence of patient characteristics further supports the argument that the immediate survival of a digit replant is more dependent on the operative proficiency of the surgeon.

This study found that increased volume increased the success of digit replantation as shown by both the logistic regression and the ROC curve. Multiple studies have demonstrated that the attempt rate of replantation is greater at higher volume replantation hospitals.^{6,18,29}

Shale et al. using the National Trauma Data Bank (NTDB) found a 16.5% attempt rate for thumb replantation, and the odds of attempting replantation was 3.4 at a high-volume center; similarly, they found similar success rates among those institutions.¹⁸ Our study, which was inclusive of all hospitals across certain states, found association in the success of replantation and hospital volume. Higher volume hospitals, including large academic institutions and extremity specialty hospitals, are not necessary designated trauma centers. Fufa et al. reported the results of digit replantation at two level 1 trauma centers and reported a success rate of 57%, but suggested that more limited volume at these institutions may have lead to declining success rates.⁴ Our results indicate that majority of digit amputation injuries are treated in lower-volume centers with 68% success rate. A hospital with greater replantation volume is more likely to attempt replantation and more likely to have a successful outcome. High volume replantation centers in the U.S. should be well known and should be considered the first choice for transferring patients with digit amputation injuries.

Lastly our study established cut-offs for annual hospital volume in regards to rate of replant success. These numbers may serve as benchmarks for institutions desiring to perform replantation and may offer some starting point for establishing centers designated for replantation. Although many other factors may effect the overall outcome of an individual replant, research indicates that hospitals and surgeons who perform complex procedures more often have better outcomes.^{5,8,30} From the standpoint of establishing guidelines for transfer, it is more helpful to target the success of an entire institution. An institution that performs more replants may also have the support staff and resources that aid more successfully performing replants. Establishing criteria for where replants should take place will help in “centralizing” the care of digit amputation injuries.

The presented study has some limitations. The success of digital replantation is largely considered to be multi-factorial. Some elements include the mechanism of injury, the quality of the amputated digit, storage of the amputated digit, access to care, the technical precision and quality of the surgery performed, health status of the patient, and proper post-operative care and monitoring.^{19,20,31} In this study, we examined number of chronic conditions recorded for injured patients. It is plausible that presence of specific illnesses such as diabetes and not number of comorbid conditions would change the probability of success for replanted digit. Prior work has established the influence of ischemia time, number of venous and arterial anastomoses, and individual surgeon volume.^{5,20,23,32} Not every single contributing factor was controlled for in this study. This study also does not reflect the function of any of the replants in regards to sensation or movement. Finger stiffness is less of a concern for the thumb because key pinch can still be maintained with fusion of the interphalangeal and/or metacarpophalangeal joint if the carpometacarpal joint is working. Additionally, the accuracy of the model in this study is dependent on the coding and accuracy within the selected databases. We were able identify and limit any duplications to provide a clean and uniform dataset to analyze. Our model tracked replants and amputations performed within a two week period. This does not reflect any subsequent amputation that might have occurred secondary to late loss, residual pain or functional limitation. Lastly under ICD-9 coding only thumb and finger are differentiated in regards to amputation and replantation. This makes the analysis of digit replantation more difficult. A ring finger may undergo replantation whereas the index or small finger may have a full or partial amputation.

We eliminated multiple episodes of digit injuries for this reason. In the newer ICD-10 coding each individual finger is identified. Finally, this study was not a nationally representative study of digit replantation. The national average might be lower or higher than what we observed in the five states included in the study. We specifically chose CA, NY, UT, FL, and NC because we were able to longitudinally follow patients for one-year period to examine the success or failure of digit replantation.

Currently transfer of amputation injuries is largely at the discretion of the outside treating physician. Informal systems among hospitals have developed based on the local or regional knowledge of which hospitals accept potential digital replant patients. Caffee and Rudnick studied hand trauma emergency care surveying both hospital and hand surgeons across a designated area. Of the 13 hospitals, 5 had hand surgery available every day, and 5 had variable coverage for hand surgery, and 3 had no hand surgery availability.³³ They found that many hand surgeons took no call or limited the availability to less than 4 days per month. The authors proposed the concept of regional hand centers with enough qualified hand staff as one solution to this problem. Similarly, Richards et al reviewed finger amputation injuries in Florida. They demonstrated that patients were being transported farther and rates of finger replantation were declining despite an increasing number of amputation injuries.³⁴ The current referral and transfer system may not emphasize the identification of digital microsurgical services, which could enhance the current trauma care system.

Hospital's digit replantation volume was associated with success of replant (better outcome). Digit replantation is a complex and expensive operation. American College of Surgeons (ACS) and American Society for Surgery of the Hand (ASSH) should be applauded for their efforts on regionalizing hand and upper extremity trauma care. Identifying high-volume digit replant centers should be a priority.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by the American Foundation for Surgery of the Hand Clinical Grant (to Dr. Elham Mahmoudi) and Midcareer Investigator Award in Patient-Oriented Research (2 K24-AR053120-06) (to Dr. Kevin C. Chung)

References

1. Masuhara K, Tamai S, Fukunishi H, Obama K, Komatsu S. Experience with reanastomosis of the amputated thumb. *Seikei Geka*. 1967; 18(4):403–404. [PubMed: 6071079]
2. Hadley SR, Capo JT. Digit Replantation The First 50 Years. *Bull Hosp Jt Dis* (2013). 2015; 73(2): 148–155. [PubMed: 26517169]
3. Mahmoudi E, Swiatek PR, Chung KC, Ayanian JZ. Racial Variation in Treatment of Traumatic Finger/Thumb Amputation: A National Comparative Study of Replantation and Revision Amputation. *Plast Reconstr Surg*. 2016; 137(3):576e–585e.
4. Fufa D, Calfee R, Wall L, Zeng W, Goldfarb C. Digit replantation: experience of two U.S. academic level-I trauma centers. *J Bone Joint Surg Am*. 2013; 95(23):2127–2134. [PubMed: 24306700]

5. Hustedt JW, Bohl DD, Champagne L. The Detrimental Effect of Decentralization in Digital Replantation in the United States: 15 Years of Evidence From the National Inpatient Sample. *J Hand Surg Am.* 2016; 41(5):593–601. [PubMed: 27021636]
6. Chung KC, Kowalski CP, Walters MR. Finger replantation in the United States: rates and resource use from the 1996 Healthcare Cost and Utilization Project. *J Hand Surg Am.* 2000; 25(6):1038–1042. [PubMed: 11119660]
7. Maroukis BL, Chung KC, MacEachern M, Mahmoudi E. Hand Trauma Care in the United States: A Literature Review. *Plast Reconstr Surg.* 2016; 137(1):100e–111e.
8. Weiland AJ, Villarreal-Rios A, Kleinert HE, Kutz J, Atasoy E, Lister G. Replantation of digits and hands: analysis of surgical techniques and functional results in 71 patients with 86 replantations. *J Hand Surg Am.* 1977; 2(1):1–12. [PubMed: 839049]
9. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. *J Trauma.* 1999; 47(3 Suppl):S46–S55. [PubMed: 10496611]
10. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma.* 1999; 47(3 Suppl):S25–S33. [PubMed: 10496607]
11. Sampalis JS, Denis R, Lavoie A, et al. Trauma care regionalization: a process-outcome evaluation. *J Trauma.* 1999; 46(4):565–579. discussion 579–581. [PubMed: 10217218]
12. Peterson BC, Mangiapani D, Kellogg R, Leversedge FJ. Hand and microvascular replantation call availability study: a national real-time survey of level-I and level-II trauma centers. *J Bone Joint Surg Am.* 2012; 94(24):e185. [PubMed: 23318624]
13. [Accessed May 2, 2016] HUCP Central Distributor SID Description of Data Elements- Multiple Variables for All States Healthcare Cost and Utilization Project (HCUP). 2008. http://www.hcup.us.ahrq.gov/db/state/siddist/sid_multivar.jsp
14. Deb, P., Manning, W., Norton, E. Preconference Course: Modeling Health Care Costs and Counts. 2010. http://www.ispor.org/OpenSourceIndex/cached/Modeling_Health_Care_Costs_and_Use_Files/ASHE2010_Minicourse_Cost_Use_slides.pdf
15. AHA Annual Survey Database Fiscal Year 2012 Documentation Manual. 2012.
16. Hanley JA, Negassa A, Forrester JE. Statistical analysis of correlated data using generalized estimating equations: an orientation. *American journal of epidemiology.* 2003; 157(4):364–375. [PubMed: 12578807]
17. Fluss R, Faraggi D, Reiser B. Estimation of the Youden index and its associated cutoff point. *Biometrical J.* 2005; 47(4):458–472.
18. Shale CM, Tidwell JE 3rd, Mulligan RP, Jupiter DC, Mahabir RC. A nationwide review of the treatment patterns of traumatic thumb amputations. *Ann Plast Surg.* 2013; 70(6):647–651. [PubMed: 23673564]
19. Ma Z, Guo F, Qi J, Xiang W, Zhang J. Effects of non-surgical factors on digital replantation survival rate: a meta-analysis. *J Hand Surg Eur Vol.* 2016; 41(2):157–163. [PubMed: 26272821]
20. Lima JQ Jr, Carli AD, Nakamoto HA, Bersani G, Crepaldi BE, de Rezende MR. Prognostic factors on survival rate of fingers replantation. *Acta Ortop Bras.* 2015; 23(1):16–18. [PubMed: 26327788]
21. Arakaki A, Tsai TM. Thumb replantation: survival factors and re-exploration in 122 cases. *J Hand Surg Br.* 1993; 18(2):152–156. [PubMed: 8501360]
22. Aziz W, Noojin F, Arakaki A, Kutz JE. Avulsion injuries of the thumb: survival factors and functional results of replantation. *Orthopedics.* 1998; 21(10):1113–1117. [PubMed: 9801235]
23. Lee BI, Chung HY, Kim WK, Kim SW, Dhong ES. The effects of the number and ratio of repaired arteries and veins on the survival rate in digital replantation. *Ann Plast Surg.* 2000; 44(3):288–294. [PubMed: 10735221]
24. Mahmoudi E, Squitieri L, Maroukis BL, Chung KC, Waljee JF. Care Transfers for Patients With Upper Extremity Trauma: Influence of Health Insurance Type. *J Hand Surg Am.* 2016
25. Butala P, Fisher MD, Blueschke G, et al. Factors associated with transfer of hand injuries to a level 1 trauma center: a descriptive analysis of 1147 cases. *Plast Reconstr Surg.* 2014; 133(4):842–848. [PubMed: 24675188]

26. Eberlin KR, Hartzell TL, Kuo P, Winograd J, Day C. Patients transferred for emergency upper extremity evaluation: does insurance status matter? *Plast Reconstr Surg.* 2013; 131(3):593–600. [PubMed: 23446571]
27. van Adrichem LN, Hovius SE, van Strik R, van der Meulen JC. The acute effect of cigarette smoking on the microcirculation of a replanted digit. *J Hand Surg Am.* 1992; 17(2):230–234. [PubMed: 1564268]
28. van Adrichem LN, Hovius SE, van Strik R, van der Meulen JC. Acute effects of cigarette smoking on microcirculation of the thumb. *Br J Plast Surg.* 1992; 45(1):9–11. [PubMed: 1737221]
29. Friedrich JB, Poppler LH, Mack CD, Rivara FP, Levin LS, Klein MB. Epidemiology of upper extremity replantation surgery in the United States. *J Hand Surg Am.* 2011; 36(11):1835–1840. [PubMed: 21975098]
30. Weiland AJ, Villarreal-Rios A, Kleinert HE, Kutz J, Atasoy E, Lister G. Replantation of digits and hands: analysis of surgical techniques and functional results in 71 patients with 86 replantations. *Clin Orthop Relat Res.* 1978; (133):195–204.
31. Yu H, Wei L, Liang B, Hou S, Wang J, Yang Y. Nonsurgical factors of digital replantation and survival rate: A metaanalysis. *Indian J Orthop.* 2015; 49(3):265–271. [PubMed: 26015624]
32. Sebastin SJ, Chung KC. A systematic review of the outcomes of replantation of distal digital amputation. *Plast Reconstr Surg.* 2011; 128(3):723–737. [PubMed: 21572379]
33. Caffee H, Rudnick C. Access to hand surgery emergency care. *Ann Plast Surg.* 2007; 58(2):207–208. [PubMed: 17245150]
34. Richards WT, Barber MK, Richards WA, Mozingo DW. Hand injuries in the state of Florida, are centers of excellence needed? *J Trauma.* 2010; 68(6):1480–1490. [PubMed: 20065873]

Figure 1.
Flow Diagram Illustrating the Patient Selection from HCUP Databases

Statistics\Hospital Annual Replantation Volume	<2	2-5	≥5
Number of hospitals	112	11	8
Number of attempted digit replant	190	147	178
Number of successful digit replant	130	94	134
Success rate	68%	64%	75%

Source: The 2008-2012 Healthcare Cost and Utilization Project State Inpatient Databases

Figure 2.

Replantation and Success Rates by Hospital Volume

Source: The 2008–2012 Healthcare Cost and Utilization Project State Inpatient Databases

Figure 3.
Receiver Operator Curve (ROC) and Optimal Hospital Cutoff Values for Success of Digit
Replantation
Source: The 2008–2012 Healthcare Cost and Utilization Project State Inpatient Databases

Table 1

Characteristics of Individuals 18 Years and Older Who Underwent Digit Replantation Between 2008–2012[†]

Patient Characteristics	Successful Digit Replantation		Failed Digit Replantation		P-value
	Mean	SD ^a	Mean	SD ^a	
No. of Cases (total, 515)	N=358		N=157		
Number of Comorbidity	0.66	0.99	0.55	0.89	0.257
Age	43.64	14.46	42.17	12.94	0.408
Female	0.10	0.30	0.13	0.34	0.364
Insurance					*0.001
Private Insurance	0.32	0.47	0.25	0.44	
Medicare	0.09	0.29	0.03	0.18	
Medicaid	0.11	0.32	0.06	0.23	
Self-pay	0.12	0.32	0.17	0.37	
Other	0.35	0.48	0.49	0.50	
Race					0.177
White	0.58	0.49	0.48	0.50	
African American	0.06	0.24	0.08	0.27	
Hispanic	0.27	0.45	0.31	0.46	
Other	0.09	0.29	0.13	0.34	
Median Household Income State Quartile					0.289
First quartile (poorest)	0.23	0.42	0.30	0.46	
Second quartile	0.29	0.46	0.25	0.43	
Third quartile	0.23	0.42	0.25	0.43	
Fourth quartile (richest)	0.24	0.43	0.20	0.40	
Length of stay (days)	4.92	3.86	6.01	5.36	*0.009

[†] From California, North Carolina, Utah, Florida and New York between 2008–2012 in Healthcare Cost and Utilization Project State Inpatient Databases and American Hospital Association Annual Survey Database in Fiscal Year 2012

^a Standard Deviation

* Significantly different between success and failure groups at the 95% confidence interval.

Table 2

Regression Results Estimated by Generalized Estimating Equations Method for Probability of Success of Digit Replantation after a Traumatic Amputation [†]

Explanatory Variables	OR	95% CI ^a	P-value
N= 515			
Number of Comorbid Conditions	1.08	0.86–1.36	0.499
Age	0.99	0.97–1.01	0.467
Female	0.57	0.31–1.08	0.085
Payer			
Private Insurance (ref)	1.00		
Medicare	3.03	1.17–7.87	*0.023
Medicaid	2.14	1.10–4.15	*0.025
No Insurance	0.61	0.31–1.20	0.151
No charge and others	0.58	0.37–0.92	*0.021
Race/Ethnicity			
White (ref)	1.00		
African American	0.93	0.46–1.89	0.840
Hispanic	0.86	0.55–1.36	0.523
Others	0.63	0.34–1.18	0.148
Median Household Income State Quartile			
First quartile (ref)	1.00		
Second quartile	1.62	0.90–2.93	0.108
Third quartile	1.07	0.65–1.78	0.789
Fourth quartile (richest)	1.59	0.92–2.74	0.094
Length of Stay (days)	0.93	0.89–0.97	*0.001
Annual Hospital Replantation Volume	1.06	1.02–1.10	*0.003

[†]From California, North Carolina, Utah, Florida and New York between 2008–2012 in Healthcare Cost and Utilization Project State Inpatient Databases and American Hospital Association Annual Survey Database in Fiscal Year 2012

^aConfidence Interval

*Significant at the 95% confidence interval.