Comparison of skin stapling devices and standard sutures for pediatric scalp lacerations: A randomized study of cost and time benefits

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Objective: **To compare the total costs and the physician time requirements for suture and staple repair of pediatric scalp lacerations.**
Study design: **Eighty-eight children, 13 months to 16 years of age, coming to a children's hospital emergency department with simple scalp lacerations were prospectively randomly selected to receive staple or suture repair. Wound lengths, times required for initial wound care and closure, and equipment use were recorded. Patients returned in 1 week for suture or staple removal and wound reevaluation. The two methods were compared in terms of both time expended and costs of equipment and physician compensation.**
Results: **Forty-five children underwent staple repair and 43 underwent suture repair. There were no differences in age, sex, wound length, number of sutures or staples per centimeter, or physician experience. Stapling resulted in shorter wound closure times (65 vs 397 seconds; $p < 0.0001$) and shorter overall times for wound care and closure (395 vs 752 seconds; $p < 0.0001$). Staple repair was less expensive in terms of equipment ($12.55 vs $17.59; $p < 0.0001$) and total cost based on equipment and physician time ($23.55 vs $38.51; $p < 0.0001$). The follow-up rate was 91%, with no cosmetic or infectious complications in either group.**
Conclusions: **Stapling is faster and less expensive than suturing in the repair of uncomplicated pediatric scalp lacerations, with no additional complications. Physicians who treat children with scalp lacerations should consider the use of stapling devices. (J Pediatr 1997;130:808-13)**

The repair of skin lacerations is a significant part of pediatric emergency practice. Minor trauma is the leading diagnostic category for pediatric visits to emergency departments, constituting 22% of visits to pediatric EDs[1] and 42% of visits to general community EDs.[2] Lacerations account for more than a fourth of minor injury visits and comprise between 4.4% and 11% of all visits to EDs.[2, 3]

Automatic disposable stapling devices have long been used in the operating room and have been extensively discussed in the surgical literature. A small number of ED-based studies exist on the use of staples in the repair of traumatic skin wounds. When compared with sutures, staples were nearly five to seven times faster and were found to produce equivalent cosmetic results.[4, 5] Previous studies have sug-

ED	Emergency department
TAC	Tetracaine-adrenaline-cocaine

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gested potential cost savings, but only one has specifically considered the cost of personnel time in the treatment of adults.[6]

Developmental and behavioral considerations contribute to the challenge of pediatric wound management and make rapidity and ease of execution particularly desirable. In addition, patient behavior may influence the relative efficacy of laceration repair methods. We hypothesized that the use of automatic stapling devices would result in time and cost savings in the ED repair of simple pediatric scalp lacerations in comparison with standard suture repair, with no significant increase in complication rates.

METHODS

Childrens Hospital treats more than 60,000 ED patients annually. Lacerations and other injuries are managed in a separate trauma area staffed by pediatric residents and pediatric emergency medicine fellows under the supervision of attending physicians. Patients less than 18 years of age with scalp lacerations were eligible for study participation if their wounds were recent (<12 hours old), linear or curvilinear, smooth edged (not requiring debridement), and entirely confined to the hair-bearing area. The patients were required to be in generally good health and specifically free of conditions known to impede wound healing (including diabetes mellitus, rheumatologic or vasculitic diseases, malignancy, congenital or acquired immunodeficiencies, cardiopulmonary conditions resulting in hypoxemia, and systemic therapy with cytotoxic, antineoplastic, or corticosteroid medications). Exclusion criteria included requirement for a deep suture layer, severe comorbidity, requirement for inpatient management or general anesthesia, and inability or refusal to return for subsequent care. The study protocol and consent form were reviewed and approved by the hospital's committee on clinical investigations, and informed consent was obtained from the patient's parent or guardian (and from the patient, if ≥12 years of age).

Enrollees were randomly assigned to one of two repair methods: disposable skin stapler (staple group) or monofilament nonabsorbable suture (suture group). A randomization scheme, balanced in blocks of 10 (5 subjects per repair method), was created with a random-number table, with group assignment sealed in sequentially numbered study packets and known only after enrollment. Wound repair was performed by physicians at the upper-level resident or fellow level. Wounds in the suture group were closed with a single layer of simple interrupted sutures of monofilament nylon or polypropylene by using a cutting type of needle, and those in the staple group with an automatic disposable stapler (Precise DS-5 and DS-15, 3M, St. Paul, Minn.) by using the technique recommended by the manufacturer.

Patient data included age, sex, mechanism of injury, site of wound, length of wound, and age of wound. Self-report of pain before and during repair was elicited from patients more than 3 years of age and able to cooperate with the use of a 5-point scale of facial expressions corresponding to various degrees of pain (1, no pain; 5, maximal pain).[7]

Procedure-related data included duration of procedure, number of sutures or staples placed, number of packages and type of staples or sutures used, and use of restraint, local anesthetics, and sedation. The incidence of potentially infectious exposures (skin or glove puncture and loss of sharp devices) was recorded. Duration of repair was measured in seconds by an individual not performing the repair and was recorded as two separate periods: wound preparation (including application of antiseptic solution, injection of anesthetic, and irrigation) and wound repair (timed from the beginning of placement of the first suture or staple until the completion of the last). The application of tetracaine-adrenaline-cocaine, if used, was not included in these periods.

Immediately after repair the physicians completed a checklist of all supplies used and elicited a measure of parent satisfaction by asking whether the child tolerated the procedure better than, worse than, or as expected. Material costs are based on costs to the hospital at the time the study was conducted. Expenditures for physician time are calculated by multiplying wound preparation and closure times by a rate of reimbursement for ED physicians ($100/hr) based on data collected by two emergency medicine professional societies (American College of Emergency Physicians, unpublished data, 1991; S. L. Kristal and B. M. Thompson, Society for Academic Emergency Medicine, unpublished data, 1993).

Because of the different levels of expertise among the participating physicians, we were concerned with the ability to generalize our results, particularly those derived from residents less experienced in wound repair. Therefore the repairs done by fellows were studied separately to determine whether the differences between stapling and suturing persisted with more experienced physicians. These calculations were based on the rate of compensation for pediatric emergency medicine fellows during the study.

Patients returned for reexamination and staple or suture removal in 7 days. Data collected at follow-up included persistence of pain, complication or difficulty as perceived by a parent, presence of wound infection or dehiscence, and difficulty of removal.

Sample size estimation and data analysis. With the use of duration of procedure and cost of repair as principal outcome indicators, a sample size of 20 patients per group was calculated on the basis of a detectable difference of 1 SD ($\alpha = 0.05$; $\beta = 0.10$) and 44 per group for a detectable difference of 0.7 SD. Either sample size would be sufficient to demonstrate differences in the magnitude reported by Or-

Table I. Patient and wound characteristics

Characteristic	Staple group (n = 45)	Suture group (n = 43)	p
Sex (male)	37/45 (82%)	32/43 (74%)	0.374
Age (mo)*	71.4 ± 40.4 (18-201)	69.6 ± 45.3 (13-199)	0.844
Age of wound (hr)*	3.14 ± 2.49 (0.5-11.0)	2.94 ± 1.72 (0.5-8.0)†	0.669
Length (cm)*	2.25 ± 1.48 (0.4-9.0)	1.88 ± 0.79 (0.8-4.0)	0.150
Region			
Parietal	21/45 (47%)	16/43 (37%)	
Occipital	16/45 (36%)	19/43 (44%)	0.205
Frontal	5/45 (11%)	8/43 (19%)	
Temporal	3/45 (7%)	0/43 (0%)	
Physician level (fellow)	26/45 (58%)	25/43 (58%)	0.973
Cooperative with pain scale	33/45 (73%)	27/43 (63%)	0.289
Pain score, before pair			
1	16/33 (48%)	16/27 (59%)	
2	12/33 (36%)	7/27 (26%)	0.092
3	5/33 (15%)	1/27 (4%)	
4	0/33 (0%)	3/27 (11%)	

*Data presented as mean ± SD (range).
†Based on measurements from 41 in suture group.

linsky et al.[6] for material costs. However, because the magnitude of SDs for speed of repair and personnel costs was not readily predictable from the available literature, the larger sample size was chosen. Statistical analyses were performed with the Student *t* test for comparison of continuous numeric data, and with the chi-squared test with continuity correction or the Fisher Exact Test for categorical data.

RESULTS

During the study period (October 1992 to May 1994), 97 patients were enrolled. Nine were disqualified because of need for layered repair (four patients), insufficient data collection (three), withdrawal after enrollment (one patient), and ineligibility discovered after enrollment (one). The remaining 88 patients, 69 boys and 19 girls, completed random assignment and repair according to protocol, with 45 in the staple and 43 in the suture group. Mechanisms of injury included falls while standing or ambulating in 47 (53%), falls from a height in 18 (20%), blows by blunt or sharp objects in 21 (24%), and one case each of a human bite and a minor automobile-pedestrian collision. No statistically significant differences existed between the staple and suture groups (Table I) with respect to patient age, sex, wound age or length, or wound mechanism or location. Pain self-reports, obtained from 33 of the staple group and 27 of the suture group before repair, were similar. Wounds were repaired by second- and third-year residents (42%) in their pediatric emergency medicine rotations and by pediatric emergency medicine fellows (58%). Staples and sutures were placed in similar numbers and spacing (Table II).

Data on timing of the wound-preparation phase was missing for two subjects in the staple group and one in the suture group. Their data are included in comparisons of wound closure but excluded from calculations of overall costs. Staple and suture groups did not differ in time taken for wound preparation (Table II). However, wound closure itself was six times faster with staples ($p < 0.0001$) and eight times faster per centimeter ($p < 0.0001$). Even when wound preparation and repair times were combined, the staple group remained twice as fast ($p < 0.0001$).

Physician compensation (Table III), estimated from wound preparation and repair times, was 47% less with stapling than with suturing at attending and fellow rates of compensation ($p < 0.0001$). Equipment costs were 29% less ($p < 0.0001$), and overall costs were approximately 39% less ($p < 0.0001$) with the staple group. The difference in overall costs was smaller (31%) when calculated at the fellow rate of compensation because of the smaller contribution of physician labor costs.

When compared with residents, fellows were nearly twice as fast at suturing (177 vs 330 sec/cm; $p = 0.01$) and one and one-half times as fast at stapling, although the latter difference was not statistically significant (26 vs 40 sec/cm; $p = 0.12$). When studied separately as a more experienced and homogeneous subgroup (Table IV), fellows closed wounds six times faster with staples than with sutures and more than seven times faster per centimeter. Their equipment expenditure while using staples was 31% less and the total expenditure was 31% less, calculated at both attending and fellow rates of compensation.

Sedation was used in only one patient (suture group, $p = 1.0$). Complete information on the use of restraint was

Table II. Treatment characteristics

Characteristic	Staple group	Suture group	p
Preparation (seconds)*, †	329 ± 206 (100-1020)	354 ± 212 (90-1320)	0.583
Staples/sutures placed*	4.4 ± 2.6 (1-14)	3.7 ± 1.7 (1-9)	0.11
Spacing (cm^{-1})*	2.2 ± 0.7 (1.0-4.3)	2.1 ± 0.7 (1.0-4.0)	0.49
Repair (seconds)*	65 ± 68 (5-303)	397 ± 295 (120-1500)	<0.0001
Rate of repair (sec/cm)*	32 ± 31 (5-178)	241 ± 203 (53-975)	<0.0001
Preparation + repair (seconds)*, †	395 ± 249 (110-1080)	752 ± 432 (300-2400)	<0.0001
Cooperative with pain scale	29/45 (66%)	27/43 (63%)	0.589
Pain score, repair			
1	9/29 (31%)	11/27 (41%)	
2	8/29 (28%)	8/27 (30%)	
3	7/29 (24%)	6/27 (22%)	0.819
4	2/29 (7%)	1/27 (4%)	
5	3/29 (10%)	1/27 (4%)	

*Data presented as mean ± SD (range).
†Data based on 43 in staple group and 42 in suture group.

Table III. Cost outcomes

Outcome	Staple group	Suture group	p
Compensation, repair only	1.81 ± 1.90 (0.14-8.42)	11.02 ± 8.19 (3.33-41.67)	<0.0001
Compensation, preparation + repair*	10.98 ± 6.92 (3.06-30.00)	20.90 ± 12.00 (8.33-66.67)	<0.0001
Compensation, fellow rate, repair only	0.27 ± 0.29 (0.02-1.27)	1.67 ± 1.24 (0.50-6.30)	<0.0001
Compensation, fellow rate, preparation + repair*	1.66 ± 1.05 (0.46-4.54)	3.16 ± 1.81 (1.26-10.08)	<0.0001
Material cost	12.55 ± 4.75 (8.77-20.66)	17.59 ± 1.35 (16.75-21.99)	<0.0001
Total material + labor*	23.55 ± 9.17 (12.12-49.05)	38.51 ± 12.77 (25.87-88.66)	<0.0001
Total material + labor, fellow rate*	14.23 ± 5.12 (9.29-24.95)	20.77 ± 2.79 (18.58-32.07)	<0.0001

Data presented in dollars as mean ± SD (range). Calculations were based on emergency attending rate of compensation, except where indicated.
*Calculations based on 43 in staple group and 42 in suture group (all other calculations based on entire study population).

Table IV. Time and cost outcomes, fellow subset

Outcome	Staple group (n = 26)	Suture group (n = 25)	p
Repair (seconds)	55 ± 68 (5-303)	330 ± 233 (120-1087)	<0.0001
Rate of repair (sec/cm)	25 ± 34 (5-178)	177 ± 136 (72-712)	<0.0001
Preparation + repair (seconds)	433 ± 285 (110-1080)	631 ± 256 (300-1381)	0.0122
Compensation, repair only ($)*	0.23 ± 0.29 (0.02-1.27)	1.38 ± 0.94 (0.50-4.57)	<0.0001
Compensation, preparation + repair ($)	1.82 ± 1.20 (0.46-4.54)	2.65 ± 1.08 (1.26-5.80)	0.0122
Material cost ($)*	12.15 ± 4.73 (8.77-20.66)	17.51 ± 1.24 (16.75-21.58)	<0.0001
Total material + labor ($)*	13.96 ± 5.14 (9.37-24.95)	20.16 ± 1.86 (18.58-25.41)	<0.0001
Total material + labor, attending rate ($)	24.18 ± 10.13 (12.65-49.05)	35.04 ± 7.55 (25.87-55.90)	<0.0001

Data presented as mean ± SD (range).
*Calculations based on fellow rate of compensation.

available for 41 of the staple and 42 of the suture group. Some form of immobilization was used in 49% of the staple group and 60% of the suture group ($p = 0.446$). The subset requiring full papoose immobilization included 34% of the staple group and 52% of the suture group ($p = 0.146$). Information on anesthetic use was recorded for 40 of the staple group and 30 of the suture group. Injected lidocaine was used in 52% of the staple group and 92% of the suture group ($p = 0.0002$). The remaining patients generally received a topical anesthetic, usually TAC, although eight patients in the staple group received no anesthetic ($p = 0.005$). No difference existed in the self-reports of pain during repair (Table II). During suture repair, two suture needles were reported lost, and one glove was punctured during staple repair ($p = 0.968$), with no injuries incurred by patients or staff.

No difference was noted on simple categorization of parental satisfaction. When available for questioning, parents of 62% of the staple group (24/39) and 58% of the suture group (22/38) reported that their children fared better than expected ($p = 0.925$). Similarly, 92% (36/39) and 97% (37/

38), respectively, reported that their children were doing as well as or better than expected ($p = 0.626$).

The overall rate of return for follow-up was 91%, with similar rates for both staple and suture groups (43/45 vs 37/43; $p = 0.24$). Among the eight patients who failed to return, three chose to see their private physicians, one had follow-up denied by a managed care organization, and one patient's parent removed his or her sutures. The remaining three patients were unable to be contacted, and their outcome remains unknown. All others were doing well without complaints, and no wound complications such as dehiscence or infection were identified in either group. Several more patients in the staple group had difficulty with removal than in the suture group (9.8% vs 2.8%), but the difference was not statistically significant ($p = 0.48$).

DISCUSSION

In a busy clinical setting, rapid, safe, and inexpensive alternatives to standard suturing of pediatric lacerations are desirable. In animal models, stapled and sutured wounds demonstrated similar mechanical and histologic characteristics,[8, 9] and contaminated wounds incurred lower infection rates with staples.[10, 11] Staple repair also resulted in decreased inflammatory response, wound width, and wound closure times. Other advantages include promotion of wound-edge eversion, formation of an incomplete loop with decreased tissue strangulation, and a lack of residual cross marks.[12, 13]

A study of staple closure in elective surgical procedures[14] revealed greater speed but also a higher incidence of inflammation, wound edge inversion, scar widening, and pain up removal. In contrast, ED-based articles have reported cosmetic results comparable to those of sutured repairs,[4, 5, 15] with no differences in complication and infection rates.[4, 16] Despite a greater incidence of discomfort on removal,[4] patient satisfaction with staple closure was high, even when local anesthesia was omitted.[5]

In this pediatric ED setting, staples were six times faster than standard sutures in the closure of scalp lacerations and eight times faster per centimeter. The use of staples resulted in a 29% decrease in cost of supplies and decreases of approximately 30% to 40% for combined costs of supplies and physician compensation. No significant differences in short-term outcomes or parent satisfaction were observed. The rapidity of staple placement observed in this study is comparable to results obtained in adults.[4, 5, 15, 16] Earlier studies predicted both twofold increases[5, 16] and twofold reductions[15] in the cost of wound repair because of staple use but did not consider the effect of decreased personnel involvement. More recently, Orlinsky et al.[6] studied the costs related to both equipment and personnel time in a general ED population and found staples to be more time and cost efficient in repairs performed by physician's assistants. Our study extends this analysis to the pediatric population and further attempts to account for variations both in the use of additional minor supplies and in physician time expended in preparation for the actual repair.

Although not a primary outcome measure, pain self-reports did not differ between the two groups despite the physician's choice to omit injected anesthetic in 48% and any local anesthetic in 20% of the staple group. This approach is reasonable with short lacerations, because the pain of applying two or three staples may be less than that of local anesthetic injection and is supported by the experience in adults.[5] In addition, patient movement in response to unexpected pain is probably less likely to result in inaccurate placement or inadvertent puncture injury.

It may be difficult to generalize all of the findings of this study. Repairs were performed by a mixed group of residents and fellows in a pediatric ED setting in which minor trauma cases were geographically segregated to promote efficiency. In addition, the distribution of tasks in this study may differ from that in other settings, in which nonphysician personnel may provide some or all of the wound care. The calculations of physician compensation assume not only that additional physician time is required but also that it must be purchased specifically for each procedure. This assumption applies well to facilities such as EDs that may opt to mobilize and compensate backup physicians when overcrowding occurs. Other settings, in which staffing is inflexible, may not benefit from the reduction in physician compensation calculated for staples. Thus the same magnitude of difference may not exist for primary care settings or for providers with different levels of expertise.

Several aspects of wound care were not considered in this study. Although the obvious tasks of wound care and repair were measured, the time consumed in triage, registration, and initial and follow-up examinations was not addressed. It is likely that these aspects of care contribute equally to the overall costs of both groups. This study, in addition, does not address other methods of wound repair, such as the use of absorbable suture[17] and tissue adhesives,[18] that may provide other advantages, including avoidance of return visits and a decrease in parental inconvenience, expense, and lost wages. Similar analyses of such materials used in the repair of pediatric facial lacerations[19, 20] have shown the use of tissue adhesives to be faster, less painful, and less costly than suture repair.

No complications of staple repair were detected at the time of removal. However, the sample size limits the ability to detect differences in infrequent events such as wound infection and major cosmetic defects. Given this sample size, the occurrence of no adverse events with either technique still permits an upper limit of complication risk of 3.4%.[21]

Though not documented with statistical significance in this study, our observation was that more experience was required to remove staples rapidly and painlessly than was required for suture removal. No needle puncture accidents were reported in this series, and few incidents with potential for such injury occurred. This observation and the rapidity and accuracy of staple placement, even in a struggling child, are consistent with previous suggestions of a theoretical (and probably real) decreased risk of needle injury and disease transmission.[5, 16]

This study shows that the use of stapling devices results in faster repair of simple pediatric scalp lacerations than does the use of standard suturing. Both the costs associated with materials and physician labor are decreased by the use of staples, with no observed increase in complication rate. Although our findings are specific to the ED of a children's hospital, we recommend that all physicians who treat children with scalp lacerations become familiar with the placement and removal of skin staples to benefit from the speed and economy provided by this technique.

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