A Randomized Controlled Trial Comparing the Hair Apposition Technique With Tissue Glue to Standard Suturing in Scalp Lacerations (HAT Study)

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See editorial, p. 27.

Study objective: We evaluate a new technique of treating scalp lacerations, the hair apposition technique (HAT). After standard cleaning procedures, hair on both sides of a laceration is apposed with a single twist. This is then held with tissue adhesives. HAT was compared with standard suturing in a multicenter, randomized, prospective trial.

Methods: All linear lacerations of the scalp less than 10 cm long were included. Severely contaminated wounds, actively bleeding wounds, patients with hair strand length less than 3 cm, and hemodynamically unstable patients were excluded. Patients were randomized to receive either HAT or standard suturing, and the time to complete the wound repair was measured. All wounds were evaluated 7 days later in a nonblinded manner for satisfactory wound healing, scarring, and complications.

Results: There were 96 and 93 patients in the study and control groups, respectively. Wound healing trended toward being judged more satisfactory in the HAT group than standard suturing (100% versus 95.7%; P=.057; effect size 4.3%; 95% confidence interval 0.1% to 8.5%). Patients who underwent HAT had less scarring (6.3% versus 20.4%; P=.005), fewer overall complications (7.3% versus 21.5%; P=.005), significantly lower pain scores (median 2 versus 4; P<.001), and shorter procedure times (median 5 versus 15 minutes; P<.001). There was a trend toward less wound breakdown in the HAT group (0% versus 4.3%; P=.057). When patients were asked whether they were willing to have HAT performed in the future, 84% responded yes, 1% responded no, and 15% were unsure.

Conclusion: HAT is equally acceptable and perhaps superior to standard suturing for closing suitable scalp lacerations. Advantages include fewer complications, a shorter procedure time, less pain, no need for shaving or removal of stitches, similar or superior wound healing, and high patient acceptance. HAT has become our technique of choice for suitable scalp lacerations.

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INTRODUCTION

The ideal management of a scalp laceration would be a procedure that is painless, can be performed quickly, has a low complication rate, leaves a good functional and cosmetic result, and requires minimal follow-up care.[1] In the United States, more than 12 million traumatic wounds are treated in emergency departments every year.[2] Of these, many are traumatic lacerations of the scalp.[3]

Traditional treatment of scalp lacerations has been wound cleansing and suturing. However, patients perceive this method to be painful and slow; in addition, in cases when the hair is shaved, a bald patch results. The patient also requires a return visit for the removal of sutures.

Alternative techniques described have included stapling,[4-8] use of tissue adhesives,[9-11] and knotting of hair.[12] Knotting of hair involves using hair on either side of the wound to throw a knot, thus apposing the wound. However, because hair is smooth, the knot often slips. In addition, once the knot is tied, it can only be removed by cutting the affected hairs off. Stapling[4-8] is probably faster but has similar disadvantages of pain and the requirement of the removal of sutures.

Tissue glue is a recent innovation in wound care that has been found to be useful for skin wounds.[9-11,13] Morton et al[10] described a case series of 50 patients having scalp wounds closed by tissue adhesive. Applebaum et al[9] described a series of 30 patients with scalp wounds that were closed with knotting of the hair, which was then secured with adhesives, thus avoiding the problem of slippage of knots. Wang et al[11] reported a series of 83 scalp incisions closed with adhesives in neurosurgical patients. However, manufacturers currently do not recommend shaving of hair and applying tissue adhesives because this may impede subsequent hair growth. Furthermore, no randomized trials have been conducted to compare adhesives with sutures in scalp lacerations.

We describe a new technique for closing scalp lacerations using apposition of hair with tissue adhesives. No knotting of hair is involved. We conducted a prospective, randomized, multicenter clinical trial to compare the hair apposition technique (HAT) with standard suturing, looking specifically at wound healing, complication rates, duration of procedure, pain perception, and patient satisfaction.

MATERIALS AND METHODS

Prospective patients presenting with scalp lacerations to the EDs of 2 tertiary level hospitals were enrolled in this trial. The study began in December 1999 and ended in March 2001. The study was approved by the hospital ethics committee of both institutions involved in the trial.

A scalp laceration was defined as a break of the skin on the hair-bearing area of the head resulting usually from blunt trauma. Patients of all ages were included in the trial. Other inclusion criteria included linear, nonstellate lacerations of the scalp, wound length less than 10 cm, and presence of scalp hair at least 3 cm in length. Exclusion criteria were severely contaminated wounds, actively bleeding (arterial) wounds not stopping after application of pressure for at least 5 minutes, and unstable patients with unstable vital signs or neurologic status requiring priority resuscitation.

Eligible patients had a patient information sheet explained to them, and informed written consent was obtained. Patients were randomly assigned into either HAT or standard suturing groups using sealed envelopes generated from a table of random numbers. The allocation sequence was concealed in sequentially numbered, sealed opaque envelopes by a team not involved in trial interventions. Consent and randomization occurred before any wound preparation or closure. A minimal training period consisting of a 30-minute lecture and demonstration of the HAT technique was given to physicians involved in managing patients for the trial.

For the standard suturing group, the wound was cleaned according to standard procedure, an injection of local anesthetic was given, and shaving or trimming of the hair was performed according to local practice. The wound was then sutured, and the removal of sutures was required 1 week later. Hair washing was discour-

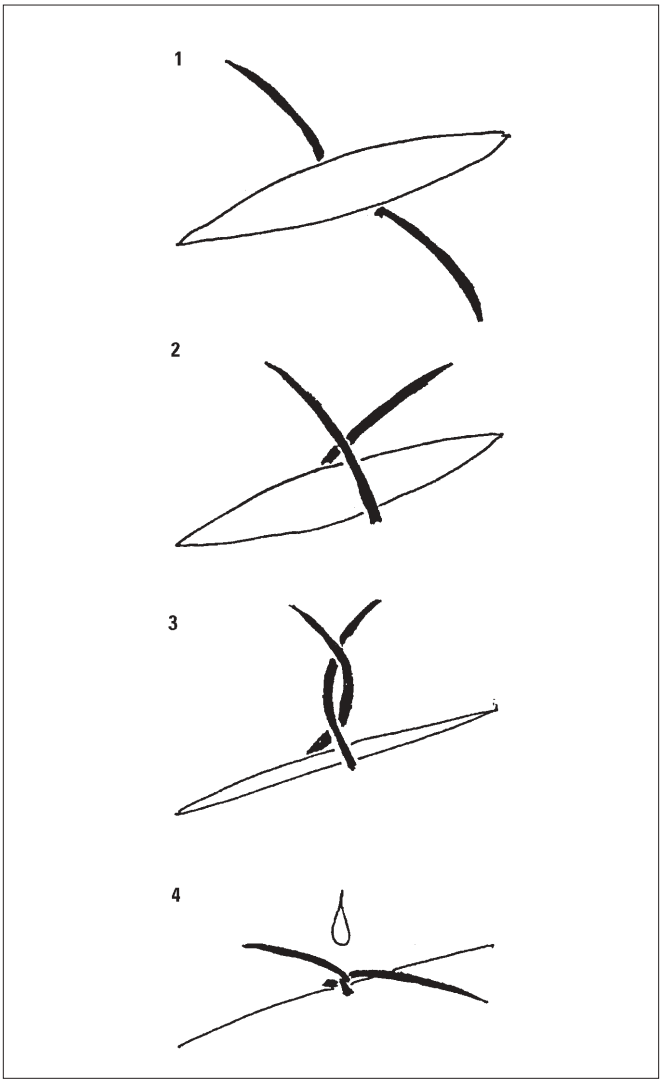
aged for a week. For very young children, oral sedation was sometimes necessary to facilitate these procedures.

For the HAT group, the wound was cleaned according to standard procedure. No local anesthetic was given. The wound was then closed by bringing together the hair on both sides of the wound. A single twist was then made. No actual knot was made. This was then secured with tissue glue (Figures 1, 2, and 3). After the procedure, the patient was instructed not to wash the wound for 2 days. No removal of stitches was required. The patient was encouraged to wash his or her hair after the third day and was told that the glue would gradually fall off. An appointment was made for the patient to return for a wound inspection 1 week later.

All procedure times were recorded to the nearest minute, by entering the start and ending time using a digital clock. The duration of procedure included wound preparation and procedure time. Pain perception was scored using a 10-point visual analog scale marked at each integer interval. Patients were asked to rate pain on a scale of 1 to 10, with 0 being no pain and 10 being the most severe, unbearable pain. All scores were to the nearest integer. An equivalent pictorial scale was used for pediatric patients to score pain (Figure 4). Patients were asked to score pain immediately after the procedure was completed.

All patients enrolled in the trial were reviewed at 7 days after the procedure. This review was performed by a senior physician who was not directly involved in the trial and was not involved in the initial treatment of the patient. Although masking of reviewers was not possible because it would be obvious which treatment the patient received, effort was made to ensure independent review. During wound review, presence of any infection, scarring, bleeding, wound breakdown, or allergy was noted. Infection, bleeding, allergy, scarring, and wound breakdown were scored as "present" or "absent." Infection was considered present if there was pus, discharge from the wound, or erythema, edema, pain, or temperature suggesting cellulitis. The complication of bleeding was considered present if there was persistent or recurrent bleeding after the procedure that would not stop after at least 5 minutes of pressure. Allergy was defined as the presence of rashes, angioedema, or anaphylaxis. Scarring was defined as the presence of a hypertrophic scar or keloid formation. Wound breakdown was considered to have occurred if any dehiscence, epidermal separation, or loss of edge apposition was present.

Figure 1.
Hair apposition technique. 1. Choose 4 to 5 strands of hair in a bundle on either side of the scalp laceration. 2. Using artery forceps, cross the strands. 3. Make a single twist to appose wound. 4. Secure with a single drop of glue.



The reviewer was also asked whether satisfactory wound healing had occurred. This was scored as "yes" or "no." Wound healing was considered satisfactory if the treatment applied had resulted in recovery of epithelial integrity and if no further treatment was required. For example, wound breakdown with dehiscence of skin margins would be considered unsatisfactory wound healing and would require further treatment (eg, resuture). However, wounds with recovery of epithelial integrity but with excessive scar tissue would usually not require any further intervention and were considered to have healed satisfactorily. Such patients would only be followed up weekly for inspections until the scar was mature.

If any wound complications were present or if healing was not complete, the patient was asked to return for weekly assessments and treatment until the complications had resolved and healing was complete.

Patient preference was also assessed. The patient was asked whether he or she would be willing to have the same procedure performed for a similar scalp laceration requiring treatment in the future. Both HAT and standard suturing groups were asked this question. Answers of "yes," "no," or "not sure" were acceptable.

Data were entered into Access 97 (Microsoft Inc., Redmond, WA) and analyzed using STATA (version 5.0, Stata Corporation, College Station, TX) statistical software. Pearson χ^2 test was used for nominal data, and

Figure 2.
The HAT procedure.

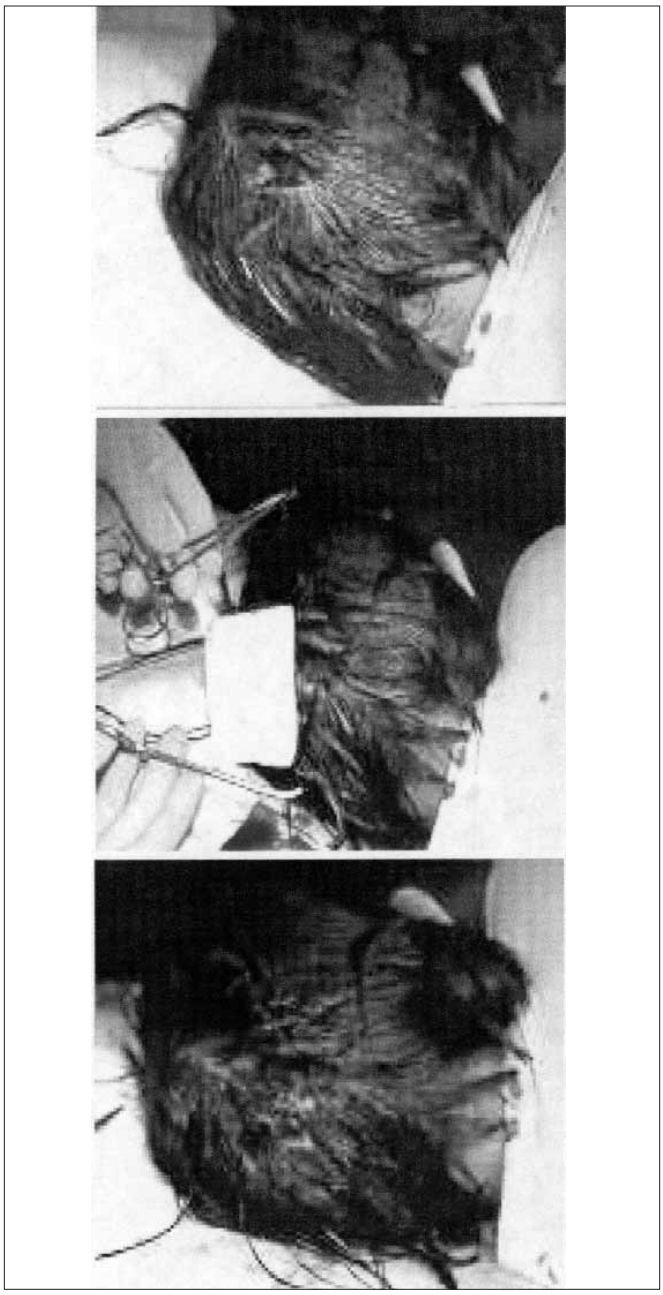
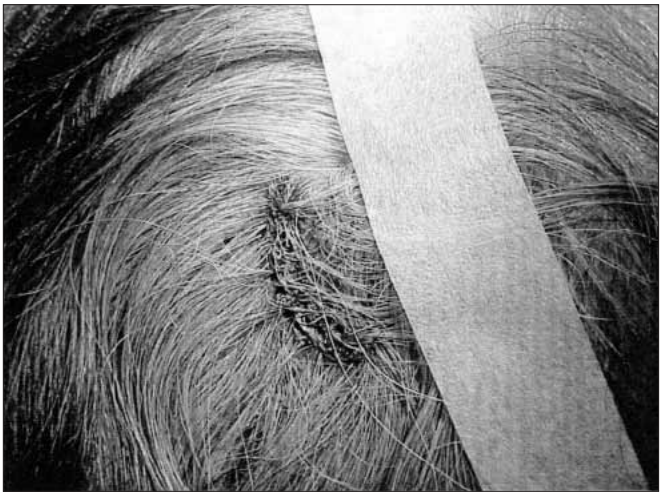


Figure 3.
A wound treated with the HAT procedure 1 week after performance of the procedure.



Fisher's exact test was used for small numbers. The Mann-Whitney *U* test was used for ordinal data, and analysis was on an intention-to-treat analysis. Primary outcome measures were the presence of any complication, namely infection, scarring, bleeding, wound breakdown, and allergy, as well as whether satisfactory wound healing had occurred. Secondary outcome measures were duration of procedure, pain perception, and patient preference. An interim analysis was planned at 100 patients to review HAT complication rates, with rules to stop the trial if complications were more than 20% above control.

RESULTS

One hundred eighty-nine patients with scalp lacerations were enrolled in the trial (Figure 5). Ninety-six were randomized to the HAT group and 93 to standard suturing. Of these, 188 patients were available for follow-up. One patient in the HAT group did not return for his review and was lost to follow-up. Two patients were randomized to the standard suturing group but were given HAT instead because of noncompliance to protocol. They were analyzed under the standard suturing group following the intention-to-treat principle. In both cases, the wound was completely healed at review 1 week after the procedure was performed, and no complications were reported.

Both groups exhibited similar demographic and wound characteristics (Table 1). Wound healing trended toward being judged more satisfactory in the HAT group than in the standard suturing group (100% versus 95.7%; *P*=.057; effect size 4.3%; 95% confidence interval [CI] 0.1% to 8.5%). Complications are shown in Table 2. For the 4 cases of wound breakdown, 1 was resutured at 1 week, another was similarly closed by HAT, and 2 were treated with daily dressings and antibiotics and were left to heal by granulation. All 4 wounds were reviewed weekly and had healed by 1 month after the procedure was initially performed. Scarring was more common with standard suturing as judged by the presence of keloid formation or a hypertrophic scar. Infection and postprocedure bleeding had no significant difference in both groups. There were no reported cases of allergy.

The HAT procedure was performed more quickly compared with standard suturing (HAT: median 5 minutes, interquartile range 5 to 10 minutes; standard suturing: median 15 minutes, interquartile range 10 to 20 minutes; *P*<.001). Patients who had HAT performed reported less pain compared with suturing (HAT: median score 2, interquartile range 0 to 3; standard suturing: median score 4, interquartile range 2 to 6; *P*<.001).

Figure 4.
Pain scale for children.

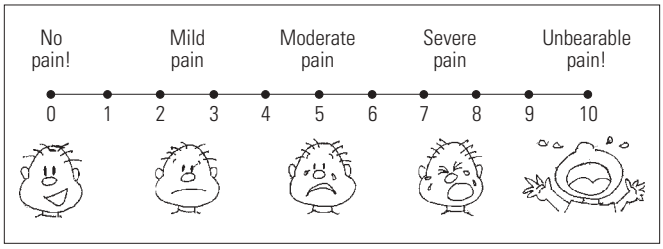
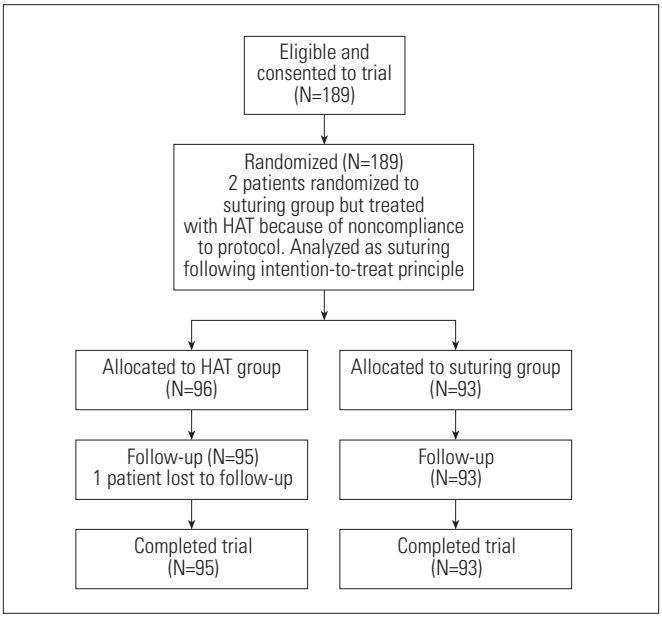


Figure 5.
Profile of the randomized controlled trial.



When asked whether they would be willing to have HAT performed in the future, 84% of patients randomized to the HAT group responded yes, 1% responded no, and the remaining 15% were unsure. However, in the suturing group, only 10% of patients said that they would be willing to have suturing performed in the future, 53% replied no, and 38% were unsure.

DISCUSSION

In this study, we found HAT to be an effective alternative treatment for patients with suitable scalp lacerations. Patients undergoing HAT were less likely to have scarring or any complications (ie, infection, scarring, bleeding, wound breakdown) and were just as likely to have satisfactory wound healing. Infection and bleeding rates were not significantly different. Wound breakdown occurred in 4 patients in the suturing group but did not occur in the HAT group. Procedure time was significantly shorter with HAT. Patients also complained of less pain and seemed to have a high acceptance of the procedure.

HAT combines the concept of using hair knotting[12] to appose a scalp wound with the advantages of using tissue adhesives.[9-11,13,14] Because no actual knot is formed, hair will fall back into place naturally once the adhesive has dropped off. Hair growth is not impaired, as is theoretically possible if the scalp is shaved and glue directly applied onto exposed hair follicles. With this technique, no shaving or trimming of hair is necessary, making it cosmetically acceptable to patients. No removal of sutures is needed, and the glue drops off after a few weeks with normal hair washing.

The use of cyanoacrylates as tissue adhesives was first described in 1959.[15] Although the early short-chain cyanoacrylates have been associated with tissue toxicity caused by rapid degradation,[16,17] the higher chain derivatives (N-2-butylcyanoacrylate and 2-octylcyanoacrylate) have been shown to have minimal if any cytotoxicity.[16-18] Numerous studies have shown that tissue adhesives are at least as good as sutures for closing skin wounds in terms of wound infection, cosmetic result, and patient acceptance.[19-24] Although there have been 3 case series reporting the use of tissue adhesives in scalp wounds,[9-11] to our knowledge, there

Table 1.
Characteristics of patients in the HAT and standard suturing groups.

Characteristic	HAT Group No. (%) (n=96)	Suturing Group No. (%) (n=93)
Age, y		
Mean (SD)	32.7 (22.5)	32.0 (19.0)
Median (range)	30 (2 to 90)	30 (1 to 79)
Sex		
Men	66 (68.8)	74 (79.6)
Women	30 (31.3)	19 (20.4)
Race		
Chinese	62 (64.6)	61 (65.6)
Malay	8 (8.3)	6 (6.5)
Indian	20 (20.8)	16 (17.2)
Other	5 (5.2)	10 (10.8)
Multiple wounds	4 (4.2)	4 (4.3)
Type of wound		
Linear	92 (95.8)	89 (95.7)
Complicated	4 (4.2)	4 (4.3)
Length of wound, cm		
Mean (SD)	2.9 (1.7)	2.6 (1.5)
Median (range)	3 (1 to 10)	2 (1 to 8)
Contamination		
Clean	79 (82.3)	75 (80.7)
Mild	15 (15.6)	17 (18.3)
Moderate	2 (2.1)	1 (1.1)
Time to treatment, h		
Median (interquartile range)	3 (2 to 4)	3 (2 to 3)
Steroids	0 (0.0)	2 (2.2)
Diabetes mellitus	3 (3.1)	4 (4.3)

Table 2.
Complications reported in patients in the HAT and suturing groups.

Complication	HAT Group, % (n=95)	Suturing Group, % (n=93)	Effect Size, % (95% CI)	*P* Value
Infection	1.1	1.1	0 (–3.0 to 3.0)	1.00
Scarring	6.3	20.4	–14.2 (–23.8 to –4.6)	.004
Bleeding	0	1.1	–1.1 (–3.2 to 1.0)	.492
Wound breakdown	0	4.3	–4.3 (–8.5 to –0.1)	.057
Any complication (ie, infection, scarring, bleeding, wound breakdown)	7.4	21.5	–14.1 (–24.1 to –4.3)	.005

have not been any previous randomized controlled trials comparing them with standard suturing for scalp lacerations.

We found in our study that suturing was associated more frequently with scarring and wound complications than HAT. This may be a result of the higher tension associated with sutures, which is a known factor for keloid formation.[25] In addition, with sutures, there is foreign body effect in the wound, which does not occur with HAT because glue is not applied directly into the wound. Although we did not find any difference in infection rates, tissue adhesives theoretically have the advantage of gram-positive antimicrobial effects and of acting as their own dressings.[26-28] However, care should be taken not to allow adhesive into the wound itself, which may cause impaired healing and foreign body reaction.[29]

Although we have not conducted any cost analysis in this study, previously reported cost analyses have shown significant cost savings using adhesives compared with sutures.[30] This is a result of reduced physician and ancillary services, reduced equipment needs, and the elimination of need for suture removal. We also use glass capillary tubings[13] to allow multiple applications (up to 10) of adhesive from 1 vial, without compromising sterility, thus providing further cost reduction. Because this is a needleless method of wound repair, the risk of a needlestick injury is also eliminated.

Limitations of this method include the fact that patients without hair or with very short strands would not be suitable candidates for HAT. Profusely bleeding scalp wounds, especially those due to arterial bleeding, would probably do better with sutures, which allows underrunning of the wound. Grossly contaminated wounds may also require trimming or shaving of the hair to allow proper cleansing and debridement. Nevertheless, our experience is that most scalp wounds seen in the ED can be suitably treated with HAT. Adequate wound cleansing is usually possible without trimming or shaving the hair.

Other limitations to this study include the inability to blind reviewers to the type of treatment given because of the necessity for removal of sutures. It was felt that compliance for follow-up longer than 1 month would have been poor, thus limiting the follow-up period. However, all patients who had wound complications or whose wound had not healed at 1 week were reviewed weekly until complete healing had occurred and complications had resolved. In addition, wound preparation was not completely standardized and varied slightly with the institution. The primary investigators were unable to be present all the time to ensure conformity of technique. However, we feel that the merit of HAT is that it is a simple technique that can be learned quickly by anyone. Scoring of pain may be quite subjective and depends on multiple psychosocial factors. Nevertheless, we believe that our results do reflect significant differences in patients' perception of pain associated with the 2 procedures. Admittedly, patient preference is also rather subjective, especially when some patients may not have experienced both procedures, thus not allowing fair comparison between the 2 techniques. However, we feel that it does give important information regarding patients' perceptions and attitudes toward the 2 techniques. A procedure that does not require injections or needles seems to be rather appealing to patients.

In conclusion, HAT may be a better technique for closing suitable scalp lacerations. Advantages include fewer complications, a shorter procedure time, less pain, no need for shaving or removal of stitches, satisfactory wound healing, and high patient acceptance. We suggest that HAT may become the procedure of choice in EDs and outpatient clinics for suitable scalp lacerations.

Author contributions: MOEH developed the HAT in his clinical practice. MOEH, SBSO, and SHL prepared the trial protocols. MEOH and SMS prepared the trial data collection forms and the database. SMS was responsible for randomization and data analysis. MOEH, SHL, and SBSO supervised the recruitment, treatment, and review of patients in the trial. MOEH drafted the manuscript and all authors contributed to the final manuscript. MOEH takes overall responsibility for the paper as a whole.

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