Management of Pediatric Forearm Torus Fractures
A Systematic Review and Meta-Analysis

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Objectives: Pediatric forearm torus fracture, a frequent reason for emergency department visits, can be immobilized by both rigid cast and nonrigid methods. However, controversy still exists regarding the optimal treatment of the disease. The aim of this study was to compare, in a systematic review, clinical efficacy of rigid cast with nonrigid methods for immobilization of the pediatric forearm torus fractures.

Methods: Literature search was performed of PubMed and Cochrane Library by 2 independent reviewers to identify randomized controlled trials comparing rigid cast with nonrigid methods for pediatric forearm torus fractures from inception to December 31, 2013, without limitation of publication language. Trial quality was assessed using the modified Jadad scale.

Results: Eight randomized controlled trials with a total of 781 participants met all inclusion criteria. The nonrigid methods for immobilization included soft cast, splint, bandage, and slab. Results showed that nonrigid immobilization had better clinical efficacy than rigid cast regarding functional recovery, treatment cost, and complication rate (relative risk, 3.02; 95% confidence interval, 1.70-5.37; P = 0.0002). Compared with rigid cast, more patients would like to choose the nonrigid methods of immobilization for future use. However, discrepant results still surround the pain levels of the patients.

Conclusions: The current study suggests that the nonrigid immobilization methods have more advantages than rigid cast for immobilization of pediatric forearm torus fracture. The former strategies are also safe enough for clinical therapy.

Key Words: torus fractures, buckle fractures, cast, splint, bandage, slab

Pediatric Emerg Care 2015;00: 00-00

Children fractures accounted for approximately 20% of all pediatric visits to the emergency department, 1 Seven percent of which involved the forearm and the wrist. 2 Of all forearm and wrist fractures in children, torus fracture is the most frequent type. 2,3 Torus fracture, also named as buckle fracture, is defined as a compression fracture of bone and normally occur in the transitional zone between the woven metaphyseal and the cortical lamellar bone. 4 Different from greenstick fracture, which usually refers to the collapse of the cortex caused by a more severe force, 5 torus fracture, which usually occurs from an unexpected fall on an outstretched hand, is an inherently stable injury with a low risk of displacement. 6-8 Because of this characteristic, various management strategies are available for clinical staff.

Cast immobilization was a traditional therapy for the treatment of torus fractures. Although this method can provide a rigid immobilization and thus promote fracture healing, it also has many disadvantages, such as heavy, bulky, and requires a second visit to the hospital for removal. These flaws of cast may bring inconvenience to children as well as their families. In recent years, many pediatric clinicians reported other methods to instead traditionally used cast, including soft cast, 9,10 futuro wrist splint, 8,11 and double Tubigrip. 11 Although patients that suffered from forearm torus fractures can be immobilized by both rigid cast and nonrigid materials, controversy still exists in the optimal treatment of this fracture.

The aim of this study was to, in a systematic review and meta-analysis, compare clinical efficacy of recently used nonrigid immobilization methods with rigid cast.

METHODS

Study Design and Search Strategy
All published randomized controlled trials (RCTs) comparing clinical efficacy of nonrigid methods with cast immobilization for pediatric forearm torus fractures were searched in PubMed and Cochrane Library by 2 independent reviewers from inception to December 31, 2013. A structured search was performed using the following search string: “torus fractures” or “buckle fractures.” There was no limitation of the publication language.

Eligibility Criteria
Only RCTs that comparing rigid cast with nonrigid methods for the immobilization of pediatric torus fractures were taken into consideration. Cohort studies, clinical controlled trials, and case reports were excluded.

Eligibility for participants were children with a definite diagnosis of torus fractures in the forearms (often confirmed by X-ray or ultrasound) and written informed consent.

Study Identification
Two reviewers independently screened titles of all the articles obtained. Any study that was potentially relevant to the topic would be reviewed in its abstract and even in its full text if inadequate information was acquired from the abstract. A third reviewer would be consulted for final decision if any disagreement on eligibility existed between the first 2 reviewers.

Methodological Quality Appraisal
Study methodological assessment was conducted using the modified Jadad scale. 12 This is an 8-item scale designed to assess randomization, blinding, withdrawals and dropouts, inclusion and exclusion criteria, adverse effects, and statistical analysis (Table 1). The score for each trial ranges from 0 (lowest quality) to 8 (highest quality). Scores of 4 to 8 denote good to excellent (high quality) and 0 to 3, poor or low quality. The critical appraisal was conducted by 2 independent reviewers, and discrepancy was solved by discussion.

Outcome Measures
Main outcome measures included functional recovery (physical and social functions), complications or problems, patient satisfaction

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Disclosure: The authors declare no conflict of interest.

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ISSN: 0749-5161

Pediatric Emergency Care • Volume 00, Number 00, Month 2015 www.pec-online.com
or preference, and future choice. Secondary outcomes were treatment costs, efficacy of home versus hospital management.

### Statistical Analysis

Statistical heterogeneity was evaluated using $I^2$ statistics, complying with Quality of Reporting of Meta-Analyses guidelines, which describe the percentage of total variation across studies that is due to heterogeneity rather than chance. $I^2$ can be readily calculated from basic results obtained from a typical meta-analysis as $I^2 = 100\% \times (Q - df)/Q$, where $Q$ is Cochrane heterogeneity statistic, and $df$ is the degrees of freedom. Substantial heterogeneity exists when $I^2$ is greater than 50%. For outcomes, when $I^2$ is greater than 0.05, a fixed-effects model was used in the meta-analysis. Otherwise, a random-effects model was adopted for $P$ of 0.05 or less. Dichotomous data were presented as relative risk and continuous variables as mean difference, both with 95% confidence intervals. The meta-analysis was performed by Review Manager 5.3 software (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). A $P$ value of 0.05 or less was considered statistically significant.

### RESULTS

#### Study Selection and Characteristics

The search procedures and search outcomes were listed in Figure 1. Altogether, 8 published RCTs with a total of 781 patients met all inclusion criteria. An RCT that compared efficacy of home and hospital managements was also included in current study for analysis. Information on general characteristics of studies and participants was listed in Table 2. The nonrigid immobilization methods included soft cast, splint, bandage, and slab.

#### Methodological Quality Assessment

Detailed scores of the included RCTs were shown in Table 3, indicating that more than half of included studies achieved high quality by the current rating system. However, the main problem reflected in nearly all studies was the neglect of blinding method for assessment as well as the method for adverse effects evaluation, which may cause biases. In addition, there was no detailed information on withdrawals and dropouts in the 2 reports.

### Complications or Problems

Plint et al found that more patients had problems in the cast group than those in the splint group (5 vs 0). Khan et al reported that more patients experienced problems in the rigid cast group than those in the soft cast group (5 of 48 vs 1 of 69, $P = 0.035$). Likewise, Oakley et al reported that more children in the encircling cast group had plaster problems than those in volar slab group (23/42 vs 10/42, $P = 0.004$). Result of the forest plot based on pooled outcomes of problems showed that cast-immobilized patients had more problems than those by other nonrigid methods (relative risk, 3.02; 95% CI, 1.70-5.37; $P = 0.0002$) (Fig. 2). With respect to the information regarding the incidence of repeat fractures, Plint et al indicated that no children were reported of refractures at 6 months follow-up time, neither in the splint group,
nor in the cast group. In addition, they also reported that no re-
fractures were identified for all of the enrolled patients at 6 months.

**Patient Comfort and Future Choice**

Davidson et al\(^8\) indicated that both splint and cast treated
patients were well tolerated, but parents would like to choose the
splint as they could remove it for bathing. West et al\(^5\) reported
that more bandage-treated patients felt comfortable or very com-
fortable than those managed by cast (83.3% vs 0%; \(P = 0.01\)).

Williams et al\(^{17}\) observed that convenience was rated significantly
higher by patients in the splint group than those in the cast group
on days 1, 3, 7, and 21 after injury. In addition, satisfaction was
also rated significantly higher in the splint group on days 1, 3,
and 21 after injury. In addition, satisfaction was
higher by patients in the splint group than those in the cast group
of all the enrolled patients at 6 months.

**TABLE 2. Characteristics of Included Studies**

<table>
<thead>
<tr>
<th>Author, Time and Country</th>
<th>Immobilization Methods</th>
<th>No. Cases</th>
<th>Sex Ratio (M/F)</th>
<th>Mean age (range)(yrs)</th>
<th>Injury side (L/R)</th>
<th>Main Outcomes Measures</th>
<th>Main Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davidson et al(^8), 2001, England</td>
<td>Standard plaster-of-Paris cast versus Futura-type splint</td>
<td>Splint: 98 Cast: 81</td>
<td>107/94</td>
<td>8.9 (2–15)</td>
<td>119/82</td>
<td>Cost-benefit analysis</td>
<td>Splint can be used for the fracture and further follow up is unnecessary.</td>
</tr>
<tr>
<td>Symons(^6), 2001, England</td>
<td>Below-elbow short-arm backslab (hospital versus home)</td>
<td>Home: 38 Hospital: 42</td>
<td>47/33</td>
<td>Home/hospital = 9.4/9.1</td>
<td>Not mentioned</td>
<td>Wrist deformity, functional recovery; complications or problems; future choice</td>
<td>It is clinically safe to manage children with buckle fractures within the community.</td>
</tr>
<tr>
<td>West et al(^5), 2005, United Kingdom</td>
<td>Soft bandage versus plaster cast (below- elbow polymer cast)</td>
<td>Bandage: 18 Cast: 21</td>
<td>Not mentioned</td>
<td>Distribution: &lt;5y: 5–10y: &gt;10 y = 1: 26 :12</td>
<td>Not mentioned</td>
<td>Comfort; pain; convenience; parental concern; range of wrist movement.</td>
<td>The authors would suggest bandage in treatment policy for torus fractures.</td>
</tr>
<tr>
<td>Plint et al(^3), 2006, Canada</td>
<td>Below-elbow short arm plaster cast versus plaster splint</td>
<td>Splint: 42 Cast : 45</td>
<td>57/30</td>
<td>Splint: 9.48 (5.12–14.17) Cast: 9.94 (5.87–13.65)</td>
<td>Not mentioned</td>
<td>ASKp, VAS, return to normal activities; refractures; problems; future choice</td>
<td>Splint-treated patients have better physical functioning and less difficulty with activities than those treated with a cast.</td>
</tr>
<tr>
<td>Khan et al(^10), 2007, Ireland</td>
<td>Soft cast vs. rigid cast</td>
<td>Soft cast: 69 Rigid cast: 48</td>
<td>68/49</td>
<td>5 (2 to 12)</td>
<td>65/52</td>
<td>Problems or complications, future choice, parental satisfaction</td>
<td>Torus fractures can be treated with a soft cast without the need for more than one fracture clinic appointment.</td>
</tr>
<tr>
<td>Oakley et al(^16), 2008, Australia</td>
<td>Plaster-of-Paris cast versus fiberglass volar slab</td>
<td>Cast: 42 Slab: 42</td>
<td>54/30</td>
<td>Cast: Slab = 8:9</td>
<td>49/35</td>
<td>Pain, VAS, return to normal work; time off work; problems, future choice.</td>
<td>Use of a slab may increase the duration of pain, especially in patients who had more severe pain at presentation.</td>
</tr>
<tr>
<td>Pountos et al(^11), 2010, United Kingdom</td>
<td>Futuro splint versus plaster cast versus double Tubigrip</td>
<td>Splint: 26 Cast: 24 Tubigrip: 29</td>
<td>47/32</td>
<td>9 (2–16)</td>
<td>Not mentioned</td>
<td>Pain scores, pediatric disability score, deformity, grip strength, range of lost movement.</td>
<td>Treating torus fractures with functional nonrigid devices (Tubigrip) results in improved function without increased discomfort or deformity.</td>
</tr>
</tbody>
</table>

M/F indicates males/females; L/R, left/right; ASKp, activities scales for kids performance version; VAS, Visual Analogue Scale.
higher percentage of patient convenience was found in bandage group (94.44% vs 14.29%, P = 0.0004).

Plint et al\textsuperscript{15} indicated that no significant difference was identified between the splint and cast groups in visual analogue score at any time during the study. Similarly, Oakley et al\textsuperscript{16} recorded that no statistical difference was found between the cast and slab groups regarding visual analogue score (50.0 vs 65.0; P = 0.06). However, they observed that slab-treated patients had a longer median time of pain duration than those in the cast group (6.0 vs 3.0 days; P = 0.009). Pountos et al\textsuperscript{11} indicated that no significant differences were observed regarding the pain scores among the splint group, cast group, and Tubigrip group (3.1 versus 2.9 versus 2.3). Although Williams et al\textsuperscript{17} indicated patients in the splint group had a higher median pain score than those in the cast group on days 1, 3, 7, 21 after trauma, no statistical differences were identified between the 2 groups.

With respect to the future choice, Plint et al\textsuperscript{15} claimed that both children and their parents would more likely to choose the splint for future use if they had torus fractures again, which was supported by Khan et al\textsuperscript{10} and Williams et al.\textsuperscript{17} However, Oakley et al\textsuperscript{16} reported that no significant difference was identified between the cast group and slab group (30 of 42 vs 31 of 42, P = 0.81).

Secondary Outcomes

Treatment Costs

Davidson et al\textsuperscript{8} reported that the total cost of a splint treatment was lower than that of a cast immobilization (65.75 vs 116.98). Although West et al\textsuperscript{5} did not provide medical costs, they believed that the cost of a bandage was certainly far below that of a plaster cast, a Futura-type splint, or a molded polymer cast. However, Khan et al\textsuperscript{10} said that soft immobilization might be more expensive than the rigid cast treatment. However, it was worthwhile because probably existed negative effects were minimized (eg, less time off school for children, less time off work for parents, released clinic spaces for other patients).

Home Versus Hospital Management

Symons et al\textsuperscript{6} compared clinical efficacy of patients treated at home or in hospital. Results showed that no significant differences were identified regarding the functional recovery and problem risks. However, patients treated at home group won more preference than those in the hospital (P < 0.001).

DISCUSSION

Results of the present study with all retrieved RCTs indicated that nonrigid immobilization methods have more advantages than rigid cast regarding better functional recovery, lower incidence of complications or problems, and mostly lower medical costs. These superiorities of these methods naturally won more satisfactions and future choices.

Some basic epidemiological information can be derived from Table 2. First, most of the patients were in their 5 to 10 age periods (especially around 9 years), which is probably due to the imbalance between increased physical activities and immature bones...
during this period. Second, boys accounted for 58.09% (431 of 742, according to 7 RCTs) of all patients. Boy dominance (1.38:1) of this injury is closely related to the fact boys are more piquant than girls. Third, more patients occurred on the left side of the body (294 vs 202, from 4 RCTs), which may be the result from anatomy difference between the two sides. Lastly, radius is the most frequently affected bone, which is probably as a consequence of the functional role it acts in the forearm.

Primary outcomes of the functional recovery revealed that most patients treated by non-rigid methods had better clinical efficacy than rigid cast in both physical and social functions. We considered it mainly because patients in the nonrigid group can move their limbs at a much earlier time and thus avoid many adverse effects of fractures. However, Oakley et al. found that more rigid cast-treated patients could resume normal activities than those in the slab group at 2 weeks. We inferred the outcome may be associated with different pain durations between the 2 groups.

Because the nonrigid treatment had a shorter immobilization time than the cast, clinicians may worry whether short immobilization time increases the incidence of complications. In addition, previous study indicated that an approximately 7% of the patients suffering from torus fractures had subsequent displacements and 2% had refractures. However, results of the present study indicated it was unnecessary to worry about the problems mentioned. On the contrary, many studies reported that the risks of adverse effects or problems during nonrigid immobilization were much lower than those of rigid cast immobilization. With regard to patient preference and future choice, although no agreement was reached, most patients showed their predilections to nonrigid immobilization, which was probably because of 2 reasons. First, flexible characteristic of the nonrigid materials makes patients more comfortable and more convenient to remove. Second, nonrigid immobilization reveals a much lower adverse effects or problems than rigid cast immobilization.

Most previous studies reported that the patients in the nonrigid immobilization group spent less than those in rigid cast group, which had 2 meanings. On one hand, the price of some materials is lower than the cast, such as bandage and splint. On the other hand, although some materials are more expensive than the cast (eg, soft cast and semirigid cast), the total cost is worthwhile. As Khan et al. and Taranu et al. indicated, using these kinds of nonrigid immobilization minimized the negative effects. Patients with nonrigid immobilization can remove their devices at home, which not only means a saving for a second visit to the hospital, but also a saving for medical resources. An RCT performed by Davidson et al. concluded similar efficacy between hospital and home cares, which may imply that hospital treatment for torus fractures is unnecessary. However, cautious attitude should be taken as the conclusion was just based on a single study.

Although we found that rigid cast immobilization has a lot of disadvantages, this never means that nonrigid immobilization methods have no defects. Nonrigid immobilizations are apt to become loose during treatment and often require reinforcement. Additionally, as children and the parents can remove the devices by themselves, adequate explanations and instructions should be informed regarding the removal time and how to deal with the potentially existing problems.

Up till today, unresolved queries still exist regarding many aspects of torus fractures. Initially, some authors stated that the final aim of torus fracture immobilization is just for pain relief, whereas others believed not. Additionally, although most previous studies recommended immobilization for at least 2 to 4 weeks, several studies also showed fine efficacy after immobilization of less than 2 weeks. Moreover, some clinicians said that a second follow-up to the clinic and 1 more X-ray examination are unnecessary. Therefore, whether adequate follow-up is essential requires more studies to testify. Finally, even 1 study reported that no adverse effects were identified after subacute treatment and concluded urgent treatment was not a must. Is it really unnecessary?

In a word, although several studies discussed the abovementioned problems, most of them are single reports or respective analyses. Future more RCTs should be performed to solve these queries.

The main limitation of the present study was the still limited number of eligible RCTs, which may cause biases. Additionally, different kind of materials used in the nonrigid immobilization as well as the lack of the consistent assessment systems may also affect the outcomes. Therefore, cautious attitudes should be taken towards the conclusions.

CONCLUSIONS

In summary, the current study suggests that nonrigid immobilization methods including soft cast, splint, bandage and slab, have more advantages than traditionally rigid cast for the treatment of pediatric forearm torus fractures. These techniques promise to be new options for clinical treatment of pediatric forearm torus fractures.

REFERENCES


