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Femoral Fractures in Adolescents: A Comparison of Four Methods of Fixation

By Leonhard E. Ramseier, MD, Joseph A. Janicki, MD, Shannon Weir, BSc, and Unni G. Narayanan, MBBS, MSc, FRCSC

Background: The optimal management of femoral fractures in adolescents is controversial. This study was performed to compare the results and complications of four methods of fixation and to determine the factors related to those complications.

Methods: We conducted a retrospective cohort study of 194 diaphyseal femoral fractures in 189 children and adolescents treated with elastic stable intramedullary nail fixation, external fixation, rigid intramedullary nail fixation, or plate fixation. After adjustment for age, weight, energy of the injury, polytrauma, fracture level and pattern, and extent of comminution, treatment outcomes were compared in terms of the length of the hospital stay, time to union, and complication rates, including loss of reduction requiring a reoperation, malunion, nonunion, refracture, infection, and the need for a reoperation other than routine hardware removal.

Results: The mean age of the patients was 13.2 years, and their mean weight was 49.5 kg. There was a loss of reduction of two of 105 fractures treated with elastic nail fixation and ten of thirty-three treated with external fixation (p < 0.001). At the time of final follow-up, five patients (two treated with external fixation and one in each of the other groups) had ≥2.0 cm of shortening. Eight of the 104 patients (105 fractures) treated with elastic nail fixation underwent a reoperation (two each because of loss of reduction, refracture, the need for trimming or advancement of the nail, and delayed union or nonunion). Sixteen patients treated with external fixation required a reoperation (ten because of loss of reduction, one for replacement of a pin complicated by infection, one for débridement of the site of a deep infection, three because of refracture, and one for lengthening). One patient treated with a rigid intramedullary nail required débridement at the site of a deep infection, and one underwent removal of a prominent distal interlocking screw. One fracture treated with plate fixation required refixation following refractures. A multivariate analysis with adjustment for baseline differences showed external fixation to be associated with a 12.41-times (95% confidence interval = 2.26 to 68.31) greater risk of loss of reduction and/or malunion than elastic stable intramedullary nail fixation.

Conclusions: External fixation was associated with the highest rate of complications in our series of adolescents treated for a femoral fracture. Although the other three methods yielded comparable outcomes, we cannot currently recommend one method of fixation for all adolescents with a femoral fracture. The choice of fixation will remain influenced by surgeon preference based on expertise and experience, patient and fracture characteristics, and patient and family preferences.

Level of Evidence: Therapeutic Level III. See Instructions to Authors for a complete description of levels of evidence.

Fractures of the femur are the most common major musculoskeletal injury in adolescents1. Femoral fractures in younger children are generally thought to heal satisfactorily irrespective of the form of treatment2, but the management of femoral fractures in adolescents presents specific challenges. As the body weight and the size of skeletally immature adolescents approach those of adults, there are greater demands on the stability afforded by implants used to treat these fractures. The ideal treatment method should provide adequate stability to permit early mobilization, preserve or optimize fracture biology, minimize scarring, avoid serious complications, and achieve these goals in a cost-effective manner. Currently, there are a number of surgical options, including rigid and flexible intramedullary nailing3,4, external fixation5, and compression or bridge plate fixation6,7 (Fig. 1). With each of these methods, there are trade-offs among these

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various goals. Consequently, the optimal method of treatment is unclear. The purpose of this study was to compare the results and complications of four different methods of fixation of femoral fractures in adolescents and to determine the factors related to these complications.

**Materials and Methods**

We conducted a retrospective cohort study of traumatic diaphyseal femoral fractures in children eleven to eighteen years of age who had been treated between 1995 and 2005 at The Hospital for Sick Children, Toronto, a level-I pediatric trauma center. Approval was obtained from the research ethics board of The Hospital for Sick Children. Patients were identified with use of the institution’s surgical database. A review of the medical records and radiographs of all eligible patients was conducted, and pathological fractures were excluded. To be included in the study, patients had to have been followed at least until radiographic or clinical union of the fracture and/or until they had regained their usual physical function. Of 210 diaphyseal femoral fractures identified during this period, 194 in 189 patients met these criteria for inclusion. The majority of the patients had open physes. The patients were characterized according to age, sex, weight, mechanism and energy of injury, whether they had sustained multiple injuries or an isolated injury, fracture level and pattern, percentage comminution (according to a modification of the classification system of Winquist and Hansen), and method of fixation. The four fracture fixation methods were elastic stable intramedullary nail fixation (105 fractures; 104 patients), external fixation (thirty-three fractures; thirty-two patients), rigid intramedullary nail fixation (thirty-seven fractures; thirty-seven patients), and plate fixation (nineteen fractures; seventeen patients). (One girl with a bilateral fracture was treated with a different fixation method on each side.)

**Age, Sex, and Body Weight (see Table E-1 in Appendix)**

The mean age of the patients was 13.2 years (range, eleven to 17.6 years). There was a wide distribution of ages in all four treatment groups. Patients in the rigid nail group were significantly older (14.5 years) than those in the elastic nail and external fixation groups (12.9 years each) and those in the plate group (13.3 years) (p < 0.001). There were 145 boys (148 fractures) and forty-four girls (forty-six fractures), and the sex distribution was similar across all four groups.

The patients had a mean weight of 49.5 kg (range, 23 to 84 kg), with a wide distribution of body weights across all four groups. The patients in the rigid nail group were, on the average, significantly heavier (55.2 kg) than those in the plate group (54.4 kg), those in the elastic nail group (47.6 kg), and those in the external fixation group (46.8 kg) (p = 0.001).

**Mechanism of Injury and Associated Trauma (see Table E-2 in Appendix)**

Various injury mechanisms were responsible for these fractures across all treatment groups. Thirty-six percent (sixty-nine) of the 194 fractures were associated with multiple injuries, including other fractures, visceral injuries, and head injuries. The proportion of fractures associated with polytrauma did not differ significantly among the four treatment groups (p = 0.24). One hundred and three (53%) of the fractures were caused by high-energy trauma, which was characterized on the basis of the mechanism of injury (a pedestrian or bicyclist struck by a motor vehicle or a motor-vehicle accident) and/or the presence of other injuries. The
rates of high-energy trauma were comparable across the four treatment groups.

Fracture Level, Pattern, and Percent Comminution
(see Table E-3 in Appendix)

There were 112 fractures involving the right femur and eighty-two involving the left femur. Five patients had a bilateral fracture. One hundred and twelve fractures (58%) involved the midpart of the femoral diaphysis, sixty-one (31%) involved the proximal third of the diaphysis, and twenty-one (11%) involved the distal third. The distribution of fracture levels did not differ significantly among the treatment groups.

Ninety-seven (50%) of the fractures were transverse, forty-seven (24%) were oblique, and fifty (26%) were spiral. The distribution of fracture patterns varied among the four treatment groups. There was a significantly higher proportion of spiral fractures and fewer transverse and oblique fractures in the treatment groups. There was a significantly higher proportion of spiral fractures and fewer transverse and oblique fractures in the treatment groups. When a significant difference was found, pairwise comparisons were performed with use of analysis of variance for continuous data and Pearson chi-square statistics for proportions. Analysis of variance was used to compare the mean lengths of the hospital stay and the time to union among the four treatment methods. When a significant difference was found, pairwise comparisons of the four different treatment groups were performed with levels of significance adjusted by Bonferroni correction to account for multiple comparisons. Medians are reported for skewed data. Complications are reported as rates. We hypothesized that malunion and/or loss of reduction requiring a reoperation would be associated with age, sex, body weight, high-energy trauma, polytrauma, increased comminution, fracture level and pattern, an open fracture, and the method of fixation. Univariate analyses were performed with use of Pearson chi-square statistics. Multiple logistic regression was utilized to test jointly the explanatory variables that were significant up to the 0.1 level in the univariate analyses. The adjusted odds ratios are presented with their respective 95% confidence intervals. Significance was set at a two-tailed level of 0.05.

Source of Funding

There was no external funding for this study.

Results

The mean follow-up time was 14.6 months.

Length of Hospital Stay (Table I)
The median hospital stay in the series (all treatment groups) was five days. The median hospital stay, which did not vary significantly among the treatment groups, was five days in the elastic nail group, seven days in the external fixation group, six days in the rigid nail group, and six days in the plate group.

Time to Union (Table I)
All fractures united, in a mean of twelve weeks (range, five to seventeen-two weeks). An increased time to union was significantly associated with the fixation type (p = 0.003), high-energy fracture (p = 0.007), polytrauma (p < 0.001), and open fracture (p = 0.006). The mean time to union (and standard deviation) was 11.2 ± 7.6 weeks in the elastic nail group, 16.1 ± 8.9 weeks in the external fixation group, 10.1 ± 4.8 weeks in the rigid nail group, and 13.1 ± 7.0 weeks in the plate group. The pairwise comparison of the time to union between the groups (adjusted...
for multiple comparisons) showed that the external fixation group had a significantly longer time to union than the elastic nail group ($p = 0.005$) and the rigid nail group ($p = 0.005$). In the multivariate model, only the fixation type ($p = 0.016$) and polytrauma ($p = 0.023$) remained significantly associated with an increased time to union. This was found to be true even when we adjusted for baseline differences in risk factors for delayed healing.

**Complications (Table II)**

There was a loss of reduction of two (2%) of the 105 fractures in the elastic nail group, ten (30%) of the thirty-three in the external fixation group, and none of those in the rigid nail or plate group ($p < 0.001$). At the time of final follow-up, malunion was noted in seven of the 105 femora in the elastic nail group, three of the thirty-three in the external fixation group, one of the thirty-seven in the rigid nail group, and one of the nineteen in the plate group ($p = 0.73$). The deformities ranged from $14^\circ$ of varus to $13^\circ$ of valgus and from $22^\circ$ of procurvatum (apex-anterior) to $20^\circ$ of recurvatum (apex-posterior). Five patients (one in the elastic nail group, two in the external fixation group, one in the rigid nail group, and one in the plate group) had a limb-length discrepancy of between 2.0 and 2.5 cm at the time of fracture union. None of these patients had an externally visible deformity or functional limitations secondary to the malalignment or shortening, and consequently they had not received any treatment by the time of this report.

### TABLE I Results

<table>
<thead>
<tr>
<th></th>
<th>Total (N = 194 Fractures, 189 Patients)</th>
<th>Elastic Nail (N = 105 Fractures, 104 Patients)</th>
<th>External Fixation (N = 33 Fractures, 32 Patients)</th>
<th>Rigid Nail (N = 37 Fractures, 37 Patients)</th>
<th>Plate (N = 19 Fractures, 17 Patients)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay (days)</td>
<td>Median 5</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>Mean (stand. dev.)</td>
<td>7.8 (9.0)</td>
<td>6.8 (10.1)</td>
<td>9 (5.5)</td>
<td>7.3 (4.5)</td>
<td>12.9 (12.7)</td>
</tr>
<tr>
<td>Mean time to union (wk)</td>
<td>12.01 (7.6)</td>
<td>11.2 (7.6)</td>
<td>16.1* (8.9)</td>
<td>10.1 (4.8)</td>
<td>13.1 (7.0)</td>
<td>0.003 (0.016†)</td>
</tr>
</tbody>
</table>

*The time to union was shown to be significantly longer in the external fixation group in pairwise comparisons with the elastic nail group (Bonferroni adjusted $p = 0.005$) and the rigid nail group (Bonferroni adjusted $p = 0.005$). †Adjusted for other baseline factors in multivariate analysis.

### TABLE II Clinically Relevant Loss of Reduction and/or Malunion

<table>
<thead>
<tr>
<th></th>
<th>Total (N = 194 Fractures, 189 Patients)</th>
<th>Elastic Nail (N = 105 Fractures, 104 Patients)</th>
<th>External Fixation (N = 33 Fractures, 32 Patients)</th>
<th>Rigid Nail (N = 37 Fractures, 37 Patients)</th>
<th>Plate (N = 19 Fractures, 17 Patients)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of reduction (resulting in reoperation and/or malunion)</td>
<td>12 (6%)</td>
<td>2 (2%)</td>
<td>10 (30%)*</td>
<td>0</td>
<td>0</td>
<td>&lt;0.001 (0.039†)</td>
</tr>
<tr>
<td>Malunion</td>
<td>12 (6%)</td>
<td>7 (7%)</td>
<td>3 (9%)</td>
<td>1 (3%)</td>
<td>1 (5%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Limb-length discrepancy of ≥2 cm</td>
<td>5 (3%)</td>
<td>1 (1%)</td>
<td>2 (6%)</td>
<td>1 (3%)</td>
<td>1 (5%)</td>
<td>0.36</td>
</tr>
<tr>
<td>Total (loss of reduction + malunion + limb-length discrepancy)</td>
<td>25 (13%)</td>
<td>10 (10%)</td>
<td>11 (33%)‡</td>
<td>2 (5%)</td>
<td>2 (11%)</td>
<td>0.004 (0.01†)</td>
</tr>
</tbody>
</table>

*In the pairwise comparisons, the rate of clinically relevant loss of reduction was significantly higher only in the external fixation group compared with the three other fixation groups (Bonferroni adjusted $p < 0.001$ in all three comparisons). †Adjusted for other baseline factors in multivariate analysis. ‡The rate of clinically relevant loss of reduction and/or malunion and/or limb-length discrepancy was shown to be significantly higher in the external fixation group in pairwise comparisons with the elastic nail group ($p = 0.002$) and the rigid nail group ($p = 0.003$) but not in the pairwise comparison with the plate group ($p = 0.09$). (All $p$ values are Bonferroni adjusted for multiple comparisons.) No significant difference was found between the elastic nail group and the rigid nail ($p = 0.41$) or plate ($p = 0.95$) group.
In the univariate analyses, the type of fixation (p < 0.001), fracture pattern (specifically, spiral fractures) (p = 0.027), and polytrauma (p = 0.09) were associated with a clinically relevant loss of reduction. In the multivariate analysis, only the fixation type (external fixation) remained significantly associated with loss of reduction (p = 0.039). Compared with elastic nail fixation, external fixation was associated with a 12.41-times (adjusted odds ratio) (95% confidence interval = 2.26 to 68.31) greater risk of loss of reduction and/or malunion (p = 0.004). Rigid nail and plate fixation were not significantly different from elastic nail fixation with regard to subsequent loss of reduction (p = 0.99). Polytrauma was associated with a 3.34-times (95% confidence interval = 0.69 to 16.31) greater risk of loss of reduction, but this association did not reach significance (p = 0.14).

Reoperations (Table III)

Eight of the 105 fractures in the elastic nail group required a reoperation. There were two instances of loss of reduction. In a fourteen-year-old boy with a bilateral femoral fracture, varus angulation of the right femur was noted one week postoperatively. This deformity was treated with plate fixation (see Appendix). In the second case, involving a fourteen-year-old girl, inadequate intraoperative imaging led to a failure to recognize that one nail had failed to engage the proximal segment; this led to varus angulation and shortening. This deformity was managed with lengthening over a nail, resulting in full correction as well as restoration of the length of the femur (Fig. 2). Two fractures with delayed union after elastic nail fixation were stabilized with rigid intramedullary nailing at seven and ten months after the initial operation. In addition, there were two refractures in patients who had been treated initially with elastic nail fixation. One occurred five months after the initial fixation and was treated with another elastic nail procedure. The other occurred at one month and was treated with closed manipulation to straighten the bent nail and restore fracture angulation. Two additional patients needed trimming or advancement of the nails because of symptomatic prominence prior to fracture union.

Sixteen of the thirty-three fractures treated with an external fixator required a total of seventeen reoperations. Loss of reduction in ten cases required a total of eleven readjustments of the external fixator with the patient under general anesthesia. There were three refractures (at six, seven, and eight months after the initial treatment), which were treated with elastic intramedullary nail, plate, and rigid intramedullary nail fixation, respectively. One patient required replacement of a pin because of an infection, and one required debridement of the site of a late-onset deep infection. One patient was taken back to the operating room for an attempt to achieve acute lengthening of a shortened fracture through immature callus; however, he had a persistent 2.5-cm limb-length discrepancy.

A deep infection developed, two months after the injury, at the site of a Grade-IIIa (Gustilo and Anderson system) open femoral fracture that had been treated with rigid nailing; the infection required debridement and antibiotic therapy. One patient treated with plate fixation had two separate refractures through the fracture site, at two and five months, along with plate and screw pull-out. Both episodes were addressed with repeat plate fixation.

Major Complications

A major complication was defined as a clinically relevant loss of reduction, a malunion or shortening, and/or a reoperation for any reason other than routine hardware removal. In the multivariate model, the factors that remained significantly associated with a major complication were fixation type (p = 0.002), polytrauma (p = 0.014), and an open fracture (p = 0.048). After adjustment for all other factors, the risk of a major complication was 6.4 times greater with external fixation than it was with elastic nail fixation (p = 0.001). The risk of a major complication did not differ significantly among the elastic nail, rigid nail, and plate fixation groups. The risk of a major complication associated with polytrauma was 3.2 times

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</thead>
<tbody>
<tr>
<td>Loss of reduction*</td>
<td>12 (13)</td>
<td>2</td>
<td>10 (11)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Malunion/shortening*</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Delayed union*</td>
<td>2</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Refracture*</td>
<td>6 (7)</td>
<td>2</td>
<td>3</td>
<td>—</td>
<td>1 (2)</td>
<td></td>
</tr>
<tr>
<td>Infection*</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Advancement/trimming nails*</td>
<td>2</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>All reoperations (no.,%)]</td>
<td>28 (14%)</td>
<td>8 (8%)</td>
<td>17 (52%)†</td>
<td>1 (3%)</td>
<td>2 (11%)</td>
<td>0.013†</td>
</tr>
</tbody>
</table>

*Number of patients (number of reoperations). †Only the external fixation group had a significantly higher reoperation rate than the other groups.
adjusted odds ratio) higher than that associated with an isolated injury (p = 0.014).

**Hardware Removal**

Forty-one (39%) of the 105 elastic nails were removed. Thirty-four were removed because of symptoms at the nail insertion site, four were removed electively because of the patient’s preference, and three were removed because of an alteration in treatment. Seven rigid intramedullary nails were also removed: three because of pain caused by prominent hardware proximally (two) or distally (one) and the remaining four because of the patient’s request. Three plates were removed: two because of local discomfort after healing, and one because of refracture.

**Discussion**

There are few published studies that specifically deal with the operative treatment of femoral fractures in adolescents. Prospective trials comparing different treatments for pediatric femoral fractures have typically been limited to younger children, and the optimal management of femoral fractures in adolescents cannot be extrapolated from those studies. In this large retrospective cohort study, we compared the results and complications associated with four different methods of operative fixation by adjusting for baseline differences in patient, injury, and fracture characteristics that very likely played a role in treatment selection.

We found that the time to union after external fixation was significantly longer than that after elastic nail fixation and rigid nail fixation. A prolonged healing time for femoral fractures treated with external fixation has been reported in the literature. It has been unclear whether this is attributable to the treatment method itself or whether it reflects the nature of the fractures that are typically treated with external fixation (e.g., open fractures). Indeed, the time for healing of open femoral fractures has been reported to be longer than that required for closed fractures. In our cohort, open fractures, high-energy injuries, and polytrauma were each significantly associated with a prolonged time to union. However, we found that, even after we adjusted for those risk factors, external fixation as well as the presence of other injuries remained significantly associated with a prolonged healing time.

Elastic stable intramedullary nailing has become an increasingly popular method of fixation of femoral fractures in children. However, few investigators have examined the results of elastic nail fixation in adolescents, and concerns have been raised about the appropriateness of this technique in older children. Ho et al. reported a higher complication rate (34%) in children over nine years of age when compared with younger children. The elastic stability afforded by flexible titanium nails can be overcome by a force that exceeds the elastic limit of these nails. There is a concern that, as the body weight and size of adolescents approach those of adults, elastic nails may not provide sufficient stability to prevent loss of reduction. In a study of 234 fractures treated with elastic stable intramedullary nailing in different centers, Moroz et al. found a five times greater risk of a poor outcome in children whose weight exceeded 49 kg. Others have found an association between obesity and the rate of complications with other treatment methods. Leet et al. found a significant association between obesity and complications with external fixation and with intramedullary nailing, reporting a complication rate of 40% in obese children (mean weight, 41.5 kg).

![Fig. 2](https://example.com/image2.png)

**Figs. 2** Shortening and malalignment after incorrect positioning of an elastic stable intramedullary nail. A: Postoperative anteroposterior radiograph, which is potentially misleading. B: Postoperative lateral radiograph revealing the extramedullary position of the nail. C: Shortening and varus angulation occurred. D: Lengthening over an intramedullary nail restored both length and alignment.
In contrast, we did not find an association between age and/or body weight and the rate of complications in the entire cohort or within any treatment group, including the elastic nail group, even after adjusting for other risk factors. The mean weight of the entire cohort was 49.5 kg, with a maximum of 84 kg. Although the adolescents who were treated with rigid intramedullary nailing or plate fixation were on the average heavier, the patients in the elastic nail group had a mean weight of 47.6 kg, with a maximum of 80 kg.

Complication rates after elastic stable intramedullary nail fixation have been associated with the severity of the comminution and the fracture stability. Sink et al. found a significantly higher rate of complications in their “length unstable” group. However, they did not account for any other risk factors. In our multivariate analysis, which was limited to adolescents, neither the extent of the comminution nor the fracture pattern had a significant association with loss of reduction or malunion in the elastic nail group.

In this cohort, the use of rigid intramedullary nails was associated with a low complication rate. Although we did not note any instance of osteonecrosis of the femoral head in our group, that is a potentially catastrophic complication. The recent introduction of trochanteric nails may address this risk, but there is at least one documented case report of osteonecrosis of the femoral head after use of a trochanteric entry point.11

In our study, plate fixation included the use of both conventional compression plates as well as submuscular bridge plates. There were too few of the latter for us to study separately the theoretical advantage of stable biological fixation through a minimally invasive approach.

This study had some limitations. Only the performance of a large randomized trial can ensure that different treatment groups are balanced with regard to all known (and unknown) prognostic factors at baseline, so that any differences in outcomes can be more credibly attributed to the different treatments. Such a trial would ideally be a multicenter study, to make the results more widely generalizable. Ours was a retrospective cohort study of patients treated by eight surgeons in a single center. Under such circumstances, the choice of fixation was inevitably subject to selection bias. However, the relatively large sample size and the efforts made to account for baseline differences in the treatment groups with use of multivariate analyses provide some reassurance that these findings are valid. Although the patients were treated over a ten-year period, we found no temporal trends with respect to outcomes in either the entire cohort or any of the four individual cohorts.

Alignment of the fracture was defined in conventional ways, with use of measurements at the fracture site to identify a clinically relevant loss of reduction (resulting in unacceptable alignment) or malunion, rather than on the basis of the mechanical axis (deviation) of the limb. The clinical relevance of the arbitrary cutoffs that we used to define abnormal alignment has yet to be confirmed. The very fact that none of the malunions were associated with a deformity that was externally appreciable by the patient, parents, or surgeon or met the surgeon’s threshold for recommending a corrective osteotomy raises questions about the validity of these definitions. Furthermore, these angular measurements, which are performed at the fracture site, do not take into account the remodeling that occurs at the physis or their differential impact on the mechanical axis of the limb based on the site of the fracture. Finally, the assessment of rotational alignment was based on clinical examination and was not consistently recorded in the charts.

In conclusion, all four treatments had satisfactory outcomes but, after adjustment for baseline differences, they were associated with specific complications and external fixation had a significantly higher complication rate than did the other three groups. We believe that, when the principles of elastic nailing are followed, titanium elastic nails can perform at least as well as other devices and most of the complications associated with this form of fixation are preventable. We found no association between age or weight and the risk of reduction loss or malunion after the use of this technique. Nevertheless, not all fractures may be suitable for elastic stable intramedullary nail fixation. Indeed, no current single technique is universally applicable to all femoral fractures in adolescents. Until evidence to the contrary is available, the choice of fixation will remain influenced by the surgeon’s preference based on expertise and experience, patient and fracture characteristics, and patient and family preferences, which can be guided by the findings of this study.

Appendix

Tables showing the baseline demographic, injury, and fracture characteristics of the study subjects and figures showing loss of reduction after elastic stable intramedullary nailing are available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on “Supporting Data”).

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References


