Original article

Proximal ulnar osteotomy in the treatment of neglected childhood Monteggia lesion

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A B S T R A C T

Introduction: The aim of our study was to analyze medium and long-term results of proximal ulnar osteotomy with and without ligament injury in neglected Monteggia injury in children.

Material and methods: This retrospective, multicenter study included 28 patients. Clinical criteria concerned the range of motion, pain and MEPI score, and radiologic criteria comprised of Storen line, head-neck ratio, radial neck angle, and signs of osteoarthritic remodeling.

Results: Twenty-eight patients were reviewed, at a mean 6 years’ follow-up (range, 2–34 years). Sixteen had proximal ulnar osteotomy without ligament reconstruction, and 12 had associated ligamentoplasty. Both groups showed significant clinical and radiological improvement, with no significant difference. Patients operated within less than 1 year had better clinical and radiographic results. There was no correlation between age at surgery and quality of results. The 5 patients who underwent condylar radial pinning showed early recurrence of dislocation and osteoarthritic remodeling. The three cases of Bado type-3 lesion had early recurrence of dislocation.

Discussion: Proximal ulnar osteotomy gives good long-term results in Bado type-1 lesions, regardless of age, if performed before 1 year, in the absence of osteoarthritic remodeling. Associated ligamentoplasty does not seem to be useful.

Level of evidence: IV (retrospective).

2. Material and method

A multicenter retrospective study was conducted in four pediatric orthopedic surgery departments, including patients who had undergone open reduction of radial head associated to proximal ulnar osteotomy for posttraumatic Monteggia lesion treated more than 3 months post-trauma, with a minimum 2 years’ follow-up. Twenty-eight patients were recruited, who had been operated on between 1976 and 2009 (16 female, 12 male), all with at least 2 years’ follow-up. Mean age at trauma was 5 years (range, 17 months to 12 years). Mean trauma-to-diagnosis interval was 7.4 months (3–36 months). Mean postoperative follow-up was 6 years (2–34 years). Mean age at follow-up was 12 years (4–43 years).

The Monteggia lesions were classified on preoperative AP and lateral elbow radiographs following Bado [7] (Table 1): 25 type I (anterior dislocation of the radial head) (Fig. 1), no type 2 (posterior dislocation), 3 type 3 (lateral dislocation) and no type 4 (dislocation of the radial head with associated fracture of both forearm bones).
Mean posterior displacement angle was 6° (0° to 29°) and mean varus 4° (0° to 23°). In 4 cases, there was preoperative radial head growth disorder, in 8 cases ectopic ossification and in 1 case, capitulum hypoplasia.

Surgery used Boyd’s posterolateral elbow approach [8]. The humeroradial joint was cleansed of fibrosis and annular ligament residue hindering radial head reduction. Proximal ulnar osteotomy was performed using an oscillating saw. The osteotomy opening allowed reduction via the interosseous membrane and was determined so as to enable reintegration of the radial head. Some teams used bone grafting of the osteotomy site. The osteotomy was then fixed in reduction by a one-third-tubular plate (Fig. 2). Radial head stability was tested in all axes of elbow motion before closure. In some cases, Bell-Tawse annular ligament reconstruction was associated in the same step [9], depending on the surgeon’s school of thought. Five patients underwent condyloradial pinning for residual intraoperative instability. The limb was immobilized in a brachial-antebrachial-palmar cast, with the forearm in neutral pronation-supination or supination, depending on the preoperative assessment results, for 4 to 6 weeks. The plate was removed as of the 6th postoperative month.

Pain, ranges of motion, stability, discomfort in everyday life and Mayo Elbow Performance Index (MEPI) [10] were assessed at last follow-up, as were radial head or capitulum deformity, osteoarthritic remodeling, frontal radial neck angle and radial head hypertrophy following Kim et al. [11]. Radial head dislocation or subluxation was assessed by tracing the Storen line, representing the radial axis [12]. Radiographic results were classified in 3 categories: good (complete reduction of the radial head without osteoarthritic remodeling of the elbow) (Fig. 3), mediocre (persistent subluxation, osteoarthritic remodeling of the elbow) and poor (dislocation of the radial head).

Osteochondral radial head lesions were found intraoperatively in 4 cases with more than 1 year’s trauma-to-surgery interval. Eight patients underwent ligamentoplasty using tricipital fascia (including 4 pediculated grafts) and 4 using antebrachial fascia (including 1 pediculated). Six patients had osteotomy site bone graft.

Statistical analysis used the Wilcoxon test and Spearman correlation test. The significance threshold was set at 5%.

### 3. Results

At last follow-up, flexion and extension showed significant improvement (P<0.05) as did MEPI, especially as regards of the range of motion and stability (P<0.01) (Table 2). Patients operated on less than 1 year post-trauma showed clinically significant improvement in flexion and MEPI (P<0.01), unlike those operated on later, the difference between these 2 groups being significant (P<0.05) (Table 3).

Table 4 presents the evolution of the various radiographic parameters. Mean radiologic consolidation time was 9 weeks. There was 1 case of non-union despite bone grafting, due to failure of osteosynthesis. Radiologic results were good in 20 cases, mediocre in 4 and poor in 4. There was a significant correlation between the quality of radiologic results and time to surgery (P=0.038).

There was no correlation between the age at surgery and the quality of radiologic or clinical results.

All the cases of recurrence of dislocation or subluxation were early, during cast immobilization or as of cast ablation (and ablation of any condyloradial pin). All 3 Bado type-3 patients showed early recurrence of dislocation; they had not had ligamentoplasty.

Patients were grouped according to associated annular ligamentoplasty (Table 5). Both groups showed significant improvement.

### Table 1

Composition of the 2 groups of patients.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ligamentoplasty group</th>
<th>No-ligamentoplasty group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Boys</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Mean age at trauma (y)</td>
<td>6 y 9 months (3–12)</td>
<td>5 y 2 months (17–9)</td>
</tr>
<tr>
<td>Mean age at surgery (y)</td>
<td>7 y 7 months (4–12)</td>
<td>6 y 7 months (4–9)</td>
</tr>
<tr>
<td>Trauma-to-surgery time (y)</td>
<td>8.5 months (3–44)</td>
<td>10.5 months (3–30)</td>
</tr>
<tr>
<td>Bado 1</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Bado 2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bado 3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bado 4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean FU (y)</td>
<td>7 y 9 months (2–34)</td>
<td>5 y 0 months (2–19)</td>
</tr>
</tbody>
</table>

### Fig. 1

Five-year-old boy consulting for unexplained anterior swelling of the anterior left elbow and flexion deficit. Elbow injury sustained during a fall from height four months previously. The radiograph shows anterior dislocation of the radial head (Bado type-1 lesion) with calcification of annular ligament remnants.

### Fig. 2

Radiograph 6 weeks after open reduction of the radial head with hypercorrective ulnar osteotomy, bone graft and ligamentoplasty.
Table 2
Mean range of motion and MEPI scores before and after surgery.

<table>
<thead>
<tr>
<th>ROM</th>
<th>Preoperative mean</th>
<th>Range</th>
<th>SD</th>
<th>Postoperative mean</th>
<th>Range</th>
<th>SD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>115</td>
<td>90–130</td>
<td>9</td>
<td>127</td>
<td>110–140</td>
<td>6</td>
<td>7*10^{-4}</td>
</tr>
<tr>
<td>Extension</td>
<td>–10</td>
<td>0–40</td>
<td>12</td>
<td>–4</td>
<td>0–25</td>
<td>7</td>
<td>0.04</td>
</tr>
<tr>
<td>Pronation</td>
<td>71</td>
<td>0–90</td>
<td>12</td>
<td>66</td>
<td>0–90</td>
<td>28</td>
<td>0.42</td>
</tr>
<tr>
<td>Supination</td>
<td>78</td>
<td>45–90</td>
<td>18</td>
<td>77</td>
<td>20–90</td>
<td>16</td>
<td>0.84</td>
</tr>
<tr>
<td>MEPI score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>70–90</td>
<td>5</td>
<td>94</td>
<td>63–100</td>
<td>10</td>
<td>2.4*10^{-2}</td>
</tr>
<tr>
<td>Pain</td>
<td>43</td>
<td>30–45</td>
<td>4</td>
<td>41</td>
<td>15–45</td>
<td>8</td>
<td>0.24</td>
</tr>
<tr>
<td>Motion</td>
<td>15</td>
<td>15–20</td>
<td>1</td>
<td>19</td>
<td>15–20</td>
<td>2</td>
<td>4.2*10^{-3}</td>
</tr>
<tr>
<td>Stability</td>
<td>0</td>
<td>0–0</td>
<td>0</td>
<td>10</td>
<td>05–10</td>
<td>1</td>
<td>4.6*10^{-6}</td>
</tr>
<tr>
<td>Daily life</td>
<td>25</td>
<td>25–25</td>
<td>0</td>
<td>24</td>
<td>15–25</td>
<td>2</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Table 3
Comparison of clinical outcomes of patients operated on before or after 1 year post-trauma.

<table>
<thead>
<tr>
<th>ROM</th>
<th>Operated on before 1 year</th>
<th>Operated on after 1 year</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>128</td>
<td>126</td>
<td>0.73</td>
</tr>
<tr>
<td>Extension</td>
<td>–2</td>
<td>–11</td>
<td>2.4*10^{-4}</td>
</tr>
<tr>
<td>Pronation</td>
<td>71</td>
<td>48</td>
<td>0.01</td>
</tr>
<tr>
<td>Supination</td>
<td>81</td>
<td>66</td>
<td>0.045</td>
</tr>
<tr>
<td>MEPI score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>96</td>
<td>90</td>
<td>0.26</td>
</tr>
<tr>
<td>Pain</td>
<td>42</td>
<td>38</td>
<td>0.57</td>
</tr>
<tr>
<td>Motion</td>
<td>19</td>
<td>18</td>
<td>0.01</td>
</tr>
<tr>
<td>Stability</td>
<td>9</td>
<td>9</td>
<td>0.8</td>
</tr>
<tr>
<td>Daily life</td>
<td>24</td>
<td>24</td>
<td>0.23</td>
</tr>
</tbody>
</table>

in clinical results at last follow-up, without significant intergroup difference.

Nor was there any significant intergroup difference in radiologic results at last follow-up. The head-neck ratio increased significantly in both groups (P < 0.01).

Nine patients had complications (Table 6). In the ligamentoplasty group, there were 2 cases of recurrence of dislocation or subluxation despite annular ligament reconstruction. Three patients developed osteoarthritis, 2 of whom had undergone condyloradial pinning; the third had been operated on 3 years after the initial trauma and showed preoperative osteoarthritic remodeling. All 5 condyloradial pinning patients showed early recurrence of dislocation, with onset of pain and osteoarthritic remodeling.

4. Discussion

The Bouyala technique provides good results in long-standing traumatic dislocation of the radial head, independently of age, when osteoarthritic remodeling is absent. Associated ligamentoplasty does not seem useful. Chronic Monteggia lesions should be treated as soon as possible. The present study sets no criteria for time to treatment or for age when osteoarthritic remodeling was absent, but patients operated on more than 1 year post-trauma showed poorer results. Opinions in the literature diverge, but without statistically significant evidence [3–6,9,11,13–18].

The present study involved certain limitations. The design was retrospective, entailing an intrinsic follow-up bias. The multicenter aspect entailed variations in surgical procedure, with ligamentoplasty being systematic in some centers and not practiced in others. Few of the patients were followed up to the end of their growth phase. MEPI has presently been validated only in adults, but there is no other elbow score for children and we therefore used the MEPI, as did Nakamura et al. [14] before us.

On the other hand, the present series was one of the largest reported. The longest chronic Monteggia lesion series were those of Tajima and Yoshizu [19], with 23 patients, and Nakamura et al. [14], with 22; the longest follow-ups are those of Wang and Chung [6] and Nakamura [14], at a mean 7 years.

Recently, Garg et al. published a series including more cases [20] (66, with a mean 5.6 years’ follow-up) but with 4 different surgical techniques. To the best of our knowledge, the present series is the only one involving a single procedure (Bouyala osteotomy) with one variant: association of ligamentoplasty or not. It is also the only series to show significant results.

Ligamentoplasty does not ensure radial head stability; some teams go so far as to consider it not useful [21]. Two patients in the present series showed recurrence of dislocation despite annular ligamentoplasty, as reported by other authors using the Bell-Tawse procedure [6]. Annular ligamentoplasty incurs a risk of radio-ulnar synostosis [22]. The present series did not feature any of the other complications attributed to ligamentoplasty: stiffness, ectopic ossification or radial head osteonecrosis [22]. The rate of recurrence of dislocation or subluxation showed a trend to be higher without ligamentoplasty, although not significantly.

For ligamentoplasty, we prefer using the tricipital fascia in the Bell-Tawse technique [9], as do most teams [4,9,13,23–27]. The drawback is that the incision has to be extended to the proximal part of the scar. Like others [2,3,6,28,29], we also use the antebrachial fascia if it is not too thin. Like Wang and Chang [6], if the graft is long enough, we leave it pediculated so as not to create an ulnar tunnel, which could induce radio-ulnar synostosis.

We perform posterior opening wedge proximal ulnar metaphyseal osteotomy. If the malunion is in varus, it is logical for the corrective osteotomy to involve a medial or posteromedial opening to enable reduction of the radial head. Some authors [6,14,30,31] perform diaphyseal osteotomy at the junction between the proximal and mid-thirds, with posterior opening, also, most importantly, lengthening the ulna; they believe that ulnar distraction relieves pressure on the reduced radial head; all have reported at least 1 case of non-union. Some authors use other methods, such as progressive reduction by external fixator [32,33].

Testing radial head stability is an integral part of the procedure, but results were not always specified. Very probably, condyloradial

Table 4
Evolution of radiological measurements.

<table>
<thead>
<tr>
<th>MEPI</th>
<th>Preoperative mean</th>
<th>Range</th>
<th>SD</th>
<th>Postoperative mean</th>
<th>Range</th>
<th>SD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metaphysis/neck ratio</td>
<td>1.38</td>
<td>0.96–1.59</td>
<td>0.13</td>
<td>1.55</td>
<td>1.36–1.95</td>
<td>0.18</td>
<td>4.10^{-5}</td>
</tr>
<tr>
<td>Radial angle</td>
<td>13.6</td>
<td>8–22</td>
<td>4.43</td>
<td>12.7</td>
<td>5–29</td>
<td>4.97</td>
<td>0.17</td>
</tr>
</tbody>
</table>
pinning was used for unstable heads, although not always clearly stated in the surgical report.

The poor results of the Bouyala technique in Bado type-3 lesions were unexpected. There have been other reports of poor results in long-standing type-3 Monteggia lesion, but in series comprising just 1 or 2 cases [23]. Radial head traction via the interosseous membrane in osteotomy opening seems less effective in lateral dislocation, and the Bouyala procedure may not be the optimal attitude in such cases. If ulnar malunion is varus, the corrective osteotomy should create a medial or postero-medial opening to enable radial head reduction. There are few other treatment options. The only report of good results in long-standing type-3 Monteggia lesions was by Hirayama in a 4-case series [30]: he performed open reduction without ligamentoplasty and posterior opening wedge ulnar osteotomy with ulnar lengthening.

We believe condyloradial pinning to be contraindicated, as do some other authors [34]. It should be borne in mind that testing radial head stability intra-operatively before closure is essential, and in case of instability, the osteotomy should certainly be revised. At last follow-up, one patient who had had condyloradial pinning showed osteoarthritis and might have to undergo radial head resection at the end of growth. In the other patients, with recurrence of dislocation or subluxation after condyloradial pinning, functional prognosis for the elbow appeared poor.

Rodgers et al. reported enlargement and early closure of the radial epiphysis [35]. The ratio described by Kim [11] and recently used by others such as Nakamura [14] seems appropriate at the time of the initial lesion but less so at longer term. It is classical to assess this ratio in long-standing Monteggia lesions; measured on the healthy side at end of growth, it was greater than 1.5, indicating radial head hypertrophy. We are skeptical of the interest of assessing the ratio at long term, as measurements on healthy adult heads systematically seem to indicate hypertrophy.

5. Conclusion

The Bouyala technique is presently the most widely used treatment for long-standing traumatic dislocation of the radial head, independently of age, in absence of osteoarthritic remodeling, and should preferably be performed within 1 year of trauma.

Table 5
Comparison of clinical outcomes between ligamentoplasty and no-ligamentoplasty.

<table>
<thead>
<tr>
<th>ROM</th>
<th>Ligamentoplasty</th>
<th>No-ligamentoplasty</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>128</td>
<td>126</td>
<td>0.15</td>
</tr>
<tr>
<td>Extension</td>
<td>−1.5</td>
<td>−11</td>
<td>0.53</td>
</tr>
<tr>
<td>Pronation</td>
<td>71</td>
<td>49</td>
<td>0.59</td>
</tr>
<tr>
<td>Supination</td>
<td>81</td>
<td>64</td>
<td>0.75</td>
</tr>
<tr>
<td>MEPF score</td>
<td>Total</td>
<td>96</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Pain</td>
<td>42</td>
<td>38</td>
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<tr>
<td></td>
<td>Motion</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Stability</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Daily life</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 6
Complications in each group.

<table>
<thead>
<tr>
<th></th>
<th>Ligamentoplasty group</th>
<th>No-ligamentoplasty group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Persistent dislocation or subluxation</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Need for surgical revision</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Radio-ulnar synostosis</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Non-union</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pain, blockage</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Stiffness</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Cubitus valgus</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Scar blemish</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
Ligamentoplasty does not seem to be useful, to judge from the present results. Condylar radial pinning is contraindicated. Results are poorer in neglected Bado type-3 lesions.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References
