Assessment of joint position sense deficit, muscular impairment and postural disorder following hemi-Castaing ankle ligamentoplasty

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Introduction: Hemi-Castaing ligamentoplasty is a treatment for chronic ankle instability, accused of weakening a powerful stabilizing muscle: the peroneus brevis.

Objectives: To assess proprioceptive and muscular impairment following hemi-Castaing and impact on postural control.

Methodology: A retrospective series of 21 patients underwent clinical (Karlsson, AOFAS) and proprioceptive assessment with isokinetic assessment (evertors and invertors) on a Con-Trex® dynamometer and postural assessment on a Win-Posturo® force platform, at a minimum 6 months postsurgery.

Results: At a mean 18 months' follow-up, mean Karlsson score was 84 and AOFAS score 88. Ankle joint position sense error was less on the operated than on the healthy side. Evertor strength deficit with respect to the healthy side was 4.7% (ns) at 30°/s and 5.7% (ns) at 120°/s in concentric mode and 6.6% (ns) in eccentric mode. After surgery, the evertor/invertor ratio was >1 (in favor of the evertors). Postural values were significantly higher for the operated ankle.

Discussion-conclusion: Hemi-Castaing ligamentoplasty provided excellent clinical and functional results. It did not disturb the agonist/antagonist balance of the ankle muscles, and harvesting a half peroneus brevis did not impair evertor isokinetic force. Joint position sense was not impaired; indeed, deficits with respect to the contralateral side showed improvement.

Level of evidence: Retrospective study.
To the best of our knowledge, there have been no reports of objective results for joint position sense, evertor force and postural stability following hemi-Castaing ligamentoplasty. The present hypothesis was that sacrificing a hemi-peroneus brevis significantly impairs the above functions. The objective of the present study was to analyze proprioceptive and muscular recovery and the impact on postural control following hemi-Castaing ankle ligamentoplasty.

2. Material and methods

2.1. Population

A retrospective study included 21 patients (9 female, 12 male; mean age, 30.6 ± 12.4 years), treated by the hemi-Castaing procedure.

The inclusion criterion was unilateral chronic ankle instability demonstrated by LCL lesions on pre-operative MRI. Minimum follow-up was 6 months. Exclusion criteria were other factors liable to impact balance: contralateral chronic ankle instability, whether operated on or not, anterior cruciate ligament tear, whether operated on or not, and neurologic or ENT balance disorder.

All patients were managed by hemi-Castaing ligamentoplasty [14]. Anterior talofibular ligament (ATFL) retensioning was systematically associated. Six weeks’ postoperative non-weight-bearing was prescribed, with circular resin cast immobilization with the ankle held at 90°, followed by active-passive rehabilitation including muscle reinforcement and joint position sense training.

2.2. Clinical assessment

Functional results were graded, using the Karlsson [22] and AOFAS hindfoot [23] scores, as excellent (95–100), good (80–94), moderate (50–79) or poor (< 50). The Tegner activity scale [24] was assessed pre- and postoperatively.

2.3. Proprioceptive assessment

Joint position sense [25] was assessed on a Con-Trex® isokinetic dynamometer.

Patients were positioned supine, leg horizontal with a support to the calf, the knee in 80° flexion and the hip in 45° flexion. The talocrural joint was positioned in 15° dorsiflexion (Fig. 1).

In line with the literature [26], joint position was analyzed at 10° and at 20° inversion, in random order. Patients were tested 3 times for each angle, with test order randomized.

Error (in degrees) between test position and the patient’s subjective joint position sense was analyzed.

2.4. Isokinetic assessment

The Con-Trex® isokinetic dynamometer was also used for isokinetic assessment, as described in the literature [1, 27, 28]. The patient was positioned as previously. Muscle strength was assessed concentrically at 30°/s and 120°/s and eccentrically at 30°/s, after warm-up.

Peak torque, normalized to body-weight, was assessed in Newton-meter per kg, and evertor/invertor ratio (E/I) was calculated at all 3 speeds.

2.5. Postural assessment

A Win-Posturo® force platform was used to analyze pressure center displacement.

Tests were performed under bipedal weight-bearing, eyes open and eyes closed, followed by unipodal weight-bearing, eyes open, with the contralateral limb in 70° flexion at the knee and 30° flexion at the hip. Upper limbs were in neutral posture along the body.

Tests lasted 1 minute, with 30-second pauses. When patients lost balance during a test, the test was discarded and started over again.

Pressure center displacement speed, area and length were analyzed.

2.6. Statistical analysis

Normal distribution of quantitative variables was checked on quantile-quantile Q-Q plots. The parametric paired-sample Student t-test was used to compare operated and contralateral ankles.

Pearson test assessed correlations between postoperative values and functional results.

The significance threshold was set at P < 0.05.

3. Results

3.1. Clinical assessment

Twenty-one patients were followed up for a mean 18 ± 8 months postoperatively. The operated ankle was the left one in 6 cases and the right one in 15. Pre-operative MRI found 8 isolated ATFL tears and 13 associated ATFL-calcaneofibular ligament (CFL) tears. At follow-up, 1 patient showed complex regional pain syndrome, which evolved satisfactorily. There were no scar-related complications, neuroma or dysesthesia.

Mean plantar flexion was 35° on the operated and 36° on the healthy side, and mean dorsiflexion 13° and 19° respectively. Mean Tegner activity score was 7.1 ± 3.2 pre-operatively and increased significantly to 8.7 ± 3.6 postoperatively. Mean post-operative Karlsson score was 84.2 ± 23.8, and mean AOFAS score 88.1 ± 16.2.

3.2. Proprioceptive assessment

Patients underestimated ankle position with respect to that expected on the test on both healthy and operated sides. Mean error in absolute values was 1.73 ± 0.73 at 10° and 2.48 ± 1.82 at 20° on the operated side and 2.03 ± 1.1 at 10° and 2.89 ± 1.87 at 20° on the healthy side (Table 1). The differences in error according to side were non-significant.

![Image](Fig. 1. Patient positioning on Con-Trex® dynamometer for proprioceptive and muscular assessment.)
### Table 1

Ankle position sense error (degrees).

<table>
<thead>
<tr>
<th></th>
<th>Healthy side</th>
<th>Operated side</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Test 1</td>
</tr>
<tr>
<td>Test 10°</td>
<td>2.03</td>
<td>2.13</td>
</tr>
<tr>
<td>Test 20°</td>
<td>2.89</td>
<td>3.91</td>
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### Table 2

Isokinetic assessment.

<table>
<thead>
<tr>
<th></th>
<th>Contraction mode and angular speed</th>
<th>Healthy side</th>
<th>Operated side</th>
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<tbody>
<tr>
<td></td>
<td>Concentric 30 °/s</td>
<td>17.76 ± 9.33</td>
<td>13.67 ± 5.01</td>
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<tr>
<td></td>
<td>Concentric 120 °/s</td>
<td>13.14 ± 5.11</td>
<td>10.84 ± 4.03</td>
</tr>
<tr>
<td></td>
<td>Excentric 30 °/s</td>
<td>19.48 ± 7.35</td>
<td>18.26 ± 5.67</td>
</tr>
<tr>
<td>E/I ratio</td>
<td>E/I concentric 30 °/s</td>
<td>1.24 ± 0.44</td>
<td>1.12 ± 0.27</td>
</tr>
<tr>
<td></td>
<td>E/I concentric 120 °/s</td>
<td>1.16 ± 0.5</td>
<td>1.27 ± 0.27</td>
</tr>
<tr>
<td></td>
<td>E/I excentric 30 °/s</td>
<td>1.10 ± 0.43</td>
<td>1.10 ± 0.23</td>
</tr>
<tr>
<td></td>
<td>E/I excentric 120 °/s</td>
<td>1.08 ± 0.43</td>
<td>1.08 ± 0.23</td>
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</table>

* P<0.05.

### 3.3. Isokinetic assessment

Loss of invertor strength on the operated side was significant, ranging from 11.1% to 16.2% according to speed (Table 2). Loss of evertor strength was only 4.7–6.8% compared to the healthy side (non-significant). E/I ratio was systematically in favor of evertors, but with no significant difference between sides.

### 3.4. Postural assessment

Postural values were systematically greater on the operated side, with the exception of displacement area (Table 3). They did not, however, correlate significantly with functional scores or proprioceptive or muscle strength results.

### 4. Discussion

The main findings of the present study were the absence of evertor deficit and of proprioceptive disorder following hemi-Castaing ligamentoplasty.

Functional results were good or excellent in more than 85% of cases, in agreement with the data presented to the SoFCOT symposium, which reported 92% good or very good results in 51 ligamentoplasties [18].

For joint positioning sense, the literature claims that chronic ankle instability patients underestimate ankle inversion on the affected as compared to the contralateral side [29–32]. Willem et al. [26] reported 6.64° error in maximum inversion and 7.68° at 15° inversion in 52 unstable ankles. Lee et al. [33] likewise found >5° error in the affected ankle. In the present series, error on the operated side was much smaller, at 1.73–2.48°. The hemi-Castaing technique thus did not seem to hinder recovery of proprioceptive impairment.

### Table 3

Postural assessment.

<table>
<thead>
<tr>
<th></th>
<th>Healthy side</th>
<th>Operated side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (mm²)</td>
<td>246.2 ± 377</td>
<td>272.5 ± 396</td>
</tr>
<tr>
<td>Total length (mm)</td>
<td>612.4 ± 539</td>
<td>680.9 ± 369</td>
</tr>
<tr>
<td>Anteroposterior length (mm)</td>
<td>380.1 ± 461</td>
<td>419.7 ± 261</td>
</tr>
<tr>
<td>Lateromedial length (mm)</td>
<td>402.9 ± 296</td>
<td>454.8 ± 239</td>
</tr>
<tr>
<td>Speed (mm/s)</td>
<td>27.05 ± 22</td>
<td>29.95 ± 14.3</td>
</tr>
</tbody>
</table>

* P<0.05.

Regarding ankle stabilizer muscle force, evertor deficit has been frequently reported in chronic ankle instability [1,6,7,34,35]. Techniques involving peroneous harvesting have therefore been accused of weakening a muscle that is essential to combating chronic ankle instability. In the present series, however, no significant difference in evertor strength was found according to side, and there was no significant change in E/I ratio, whether excentric or concentric, in contrast to the literature on chronic ankle instability [21,34]. The hemi-Castaing procedure thus seems to disturb neither agonist/antagonist muscle balance nor evertor force. From these results, it may be hypothesized that harvesting half a peroneus brevis induced spontaneous regeneration, the muscle strength deficit associated with chronic ankle instability no longer being found postoperatively. Invertor force, on the other hand, was impaired, perhaps due to excessive plasty tensioning.

Impaired postural control is one consequence of chronic ankle instability [36–40], and in the present series persisted despite surgical correction. It did not correlate with loss of muscle strength or proprioceptive deficit; the latter may be due to a more central component, several authors having reported bilateral postural control deficit in unilateral chronic ankle instability [5,37]. It would thus be logical that these deficits should be corrected not by surgery but rather by rehabilitation techniques to improve anticipation ability. Freeman et al.’s proprioceptive rehabilitation program [41], used in the present study, now seems out-dated: it was thought that the ankle was protected by proprioceptive feedback, whereas Thonnard et al. [42] demonstrated that the time required to induce a ligamentous lesion is systematically less than peroneus brevis response time. From this, it was concluded that anticipation should enable a strategy to be adopted to avoid sprain: muscular pre-activation is to be developed [43,44], requiring novel rehabilitation techniques, such as the Myolux® orthosis. Such techniques are now being used, and seem to have an impact on neuronal plasticity, correcting bilateral postural impairment in unilateral chronic ankle instability.

### 5. Conclusion

Hemi-Castaing ankle ligamentoplasty provides excellent functional results. The harvesting of half a peroneus brevis impairs neither evertor strength nor joint position sense. Residual postural control deficits appear to be related not to evertor or proprioceptive
factors, but rather to a deficit in neuromuscular pre-activation which may be amenable to rehabilitation. Hemi-Castaing ankle ligamentoplasty thus seems to be a good indication in chronic ankle instability.

Disclosure of interest

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

References