Prognostic factors for the recovery of hand function following trapeziectomy with ligamentoplasty stabilisation

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Accepted: 17 March 2009

Summary
Introduction: Numerous procedures are in use to treat trapeziometacarpal osteoarthritis. Most of these techniques impair hand function. In a series of trapeziectomies stabilized by ligament reconstruction with tendon suspension, we investigated whether eventual parameters influenced hand function and dexterity. Hypothesis: Some parameters influence hand function recovery following trapeziectomy combined to ligamento-tendinous stabilization. Materials and methods: This is a continuous, retrospective, single surgeon series; 60 cases of thumb trapeziometacarpal osteoarthritis were treated with trapeziectomy and ligament reconstruction (40 palmaris longus, and 20 half flexor carpi radialis) with no additional metacarpopophalangeal (MCP) joint surgery. Besides assessing classical clinical outcome criteria (pain, mobility, force), we analyzed hand function: this was obtained with a questionnaire about different everyday movements. Five types of grip were included in this analysis: spherical, pinch grasp, key pinch, power grip, and precision pinch. Results: Fifty-one trapeziectomies (85%) were evaluated at an average follow-up of 7.5 years (5–11.5). Ninety-four percent of patients had good results for pain. The average Kapandji score for mobility was 9.6 (6–10) with a mean web angle at 36.5°. Hyperextension of the MCP joint occurred in 36 cases and measured an average of 26° (5°–50°). Compared to the contralateral side average strength was 97% with the Jamar dynamometer and 88% for the key pinch. The rate of satisfaction was 96%. Collapse of trapezial height was constant, and at last follow-up, the trapezial index was 50% of its preoperative initial value.

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doi:10.1016/j.otsr.2009.03.015
The results relative to hand function assessment were good in 58% of patients. The spherical grip was the most difficult to restore. The analysis of the 42% of patients with average or poor hand function showed five prognostic factors for a poor outcome: young age at surgery, persisting postoperative pain, postoperative hyperextension of the MCP joint, reduced postoperative web angle and trapezial space collapse.

Level of evidence. — Level IV. Therapeutic study.

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Introduction

Numerous surgical treatments have been described for osteoarthritis of the trapeziometacarpal joint since the Gervis trapeziectomy [1]. Trapeziectomies associated with ligament reconstruction and tendon suspension and/or interposition remain the most frequent of these, because results for pain and mobility are good [2–7]. Surgical management of trapeziometacarpal joint osteoarthritis is difficult because it must respond to three essential demands by the patient: lack of pain, good mobility and strength to improve agility in everyday movements and for different thumb-index grips. Postoperative hand function have rarely been evaluated in the literature. Nevertheless, some authors [3,5,8,9] have performed descriptive evaluations of grips without analysing the global function of the hand and its prognostic factors.

Because the thumb is central to all grasping movements, we paid special attention to hand function and its prognostic factors in the radioclinical evaluation of our series of trapeziectomies and ligament reconstruction.

Materials et methods

Materials

Our study was retrospective and continuous.

Inclusion criteria were:

- All patients who underwent surgery for osteoarthritis of the trapeziometacarpal joint or scaphotrapeziotrapezoid joint osteoarthritis by the same surgeon (DLN) from 1995 to 2001.
- The surgical technique had to include total trapeziectomy associated with ligament reconstruction with tendon suspension and/or interposition.
- During the same operation, other surgical interventions could be performed on the hand.
- The radioclinical evaluation with a follow-up of at least 5 years had to be performed by an independent observer (GM).

Exclusion criteria included:

- All trapeziometacarpal joint or scaphotrapeziotrapezoid joint osteoarthritis treated during the inclusion period by partial trapeziectomy, isolated trapeziectomy or trapeziometacarpal prosthesis.
- Lack of radioclinical evaluation with 5-year follow-up by the same observer.

Methods

Surgical technique

All patients underwent total trapeziectomy and ligament reconstruction with tendon suspension [10] performed under locoregional anesthesia (plexus nerve block) with a pneumatic tourniquet. A Gedda Moberg approach was used [11]. The trapeziectomy was always total after minimal resection of the base of the first metacarpal bone while taking care to excise all osteophytes. Two types of graft were used, initially half of a flexor carpi radialis (FCR) then our surgical technique evolved towards the use of the palmaris longus. If the palmaris longus was not available, the surgeon used half of a FCR. With these two types of graft, the ligament reconstruction procedure was always the same, as illustrated in Fig. 1. The palmaris longus graft was musculotendinous, with its proximal muscular end placed in the trapezial space to combine muscle interposition and ligament reconstruction (Fig. 1).

All patients were immobilized in a cast for 5 weeks. No surgery was performed on the metacarpophalangeal (MCP) joints of the thumb, and no pins were placed between the first two metacarpal bones.

Radioclinical assessment

We searched for any postoperative complications, especially algodystrophy and sensitivity disorders in the territory of the radial nerve branches. We also noted any reoperations. The clinical evaluation was systematic during follow-up visits. Clinical evaluation criteria included:

- Pain, whose intensity was evaluated according to a visual analogic scale (VAS), and frequency according to Alnot’s classification [12] (Table 1).
- Opposition, evaluated on the Kapandji scale and compared to preoperative opposition [13].
- Counter-opposition, evaluated on the Kapandji scale [13].
- Web space angle clinically measured with the help of a goniometer, with the thumb in anteposition. This was expressed in degrees and compared to preoperative values.
- Active hyperextension of the MCP joint during web widening was measured clinically with the help of a goniometer, with the thumb in anteposition. It was expressed in degrees and compared to preoperative values.
- Grip strength was measured with a Jamar dynamometer, and the terminolateral thumb-index pinch was measured by key pinch. Absolute strength (an average of three consecutive trials) as well as relative strength were compared to the controlateral side.
Ligament reconstruction illustrated with a Palmaris Longus (PL). Attachment of the PL to the flexor carpi radialis (FCR) then the passage externally by the endomedullary bone at the level of the medial cortical first metacarpal bone (M1). The PL is then attached to itself and the extra muscle is placed in the trapezial space to obtain an interposition. Long Thumb Abductor (LTA).

- Subjective evaluation of the time to healing, patient satisfaction, the desire to repeat or not the intervention and strength recovery.
- Finally, we also evaluated five types of grip with the help of a self-administered questionnaire (spherical, pinch grasp, key pinch, power grip and precision grip). We drafted a simple questionnaire evaluating the most common grips. For this we chose questions that had already been used and validated in other questionnaires (ADL [14], DASH [15] and Dubert et al. [16]). We then grouped different questions together according to the type of grip among the five grips being evaluated. Patients noted each of the grips as: possible with or without slight difficulty (4 points), with difficulty (2 points) or with major difficulty or impossible to perform grips (0 point). A possible score of 20 was thus obtained (Table 2). We defined a score of less or equal to 16 over 20 as average or poor hand function, because it corresponded to a minimum of one grip being impossible to perform and two grips with difficulty.

The radiographic assessment was performed using Kapandji [17] lateral and anteroposterior views. Preoperative plain X-rays were used to separate patients according to Comtet’s classification [18] (Table 3). Preoperative lateral view plain X-rays were used to measure the trapezial height (TH) and the trapezial index (TI). The TI corresponded to the TH of the length of first phalanx of the thumb [19]. Even if the reproducibility of this index has not been evaluated, we decided to analyze the TI because it limits problems of X-ray enlargement [19]. The height of the trapezial space and the TI was calculated in all follow-up X-rays performed during the first postoperative year and the final follow-up.

### Statistical study

Our statistical calculations were performed with MedCalc®, version 8.0 software. Descriptive statistics were obtained and we calculated averages, while mentioning maximal and minimal data. Comparative statistics were also performed:

- Comparison of means (with a test of comparison of means [t-test] or a Mann-Whitney test [MWT] depending on whether data distribution was normal or not, evaluated by the Agostino-Pearson test).

<table>
<thead>
<tr>
<th>Type of grip</th>
<th>Activities</th>
<th>Without or with slight difficulty</th>
<th>Average difficulty</th>
<th>Major difficulty or impossible to do</th>
<th>Result: average (minimum—maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power grip</td>
<td>Use a hammer, carry an empty suitcase by the handle or a pot...</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>3.6 (0—4)</td>
</tr>
<tr>
<td>Key pinch</td>
<td>Turn a key in the lock</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>3.7 (0—4)</td>
</tr>
<tr>
<td>Pinch grasp</td>
<td>Carry a bottle or a book by its spine</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>3.7 (0—4)</td>
</tr>
<tr>
<td>Spherical</td>
<td>Screw and unscrew a bottle or a jar</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2.7 (0—4)</td>
</tr>
<tr>
<td>Precision</td>
<td>Close the buttons on a shirt, sew, build models</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>3.5 (0—4)</td>
</tr>
</tbody>
</table>

Patients note each type of grip as possible with or without slight difficulty (4 points), possible with average difficulty (2 points) or possible with major difficulty or impossible (0 points). We obtain a score of 20. In the right hand column the average results and the minimum and maximum for the five types of grip evaluated in our series.

### Table 1 Evaluation of pain according to Alnot’s classification [12].

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description of the type of pain</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No pain</td>
<td>31</td>
</tr>
<tr>
<td>1</td>
<td>Pain during major effort</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Pain during everyday activities</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Spontaneous intermittent pain</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Continuous pain</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 3. Radioclinical stages of trapeziometacarpal osteoarthritis according to Comtet’s classification [16].

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description of lesions</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal joint space or enlarged joint space without osteophytes. Any dislocation can be reduced. Trapeziometacarpal instability without cartilage deterioration</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Lesions limited to the TM joint: joint pinching, osteophytes and dislocation which can be reduced</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>TM deterioration the same as stage 1 associated with MCP deterioration. Hyperextension can be reduced</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>TM deterioration the same as stage 1 associated with MCP damage: hyperextension cannot be reduced</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>TM deterioration associated with STT damage</td>
<td>14</td>
</tr>
</tbody>
</table>

Results

Forty-nine patients (60 osteoarthritides of the trapeziometacarpal joint of the thumb) corresponded to the inclusion criteria. This included 42 women and seven men; 11 patients underwent bilateral surgery. The average age of patients was 61 years old (41—77). Patients were right handed in 94% of cases and in 55% of cases were operated on their dominant side. According to Comtet’s classification, these trapeziometacarpal thumb joint osteoarthritides included 32 stage 1, 14 stage 2 and 14 stage 4 (Table 3).

Seven patients (nine trapeziometacarpal thumb joint osteoarthritides) could not be followed up for at least 5 years (two patients died, five were lost to follow-up). At the last follow-up, 42 patients with 51 trapeziectomies (85%) were evaluated.

The average follow-up was 7.5 years (5—11.5). A half FCR was transplanted in 14 cases and PL 37 times. Five neurolyses of the median nerve (one in open surgery, and four endoscopically), treatment of a trigger finger and resection of a synovial cyst of the thumb, were performed during the same operation. The main complication was reflex sympathetic dystrophy in six cases (12%). In three cases, patients mentioned dysesthesia in the territory of the radial nerve.

Clinical results

Twenty thumbs were painful in the last follow-up, with an average intensity evaluated as 3/10 (1—6) on the VAS. According to Alnot’s classification, the results for pain were good in 48 cases (94%) (stage 0 or 1) (Table 1). Average opposition was 9.6 (6—10) which was not significantly different from preoperative opposition (9.1 [5—10]) (p > 0.05 [MWT]). Counter-opposition was possible in 42 patients, and measured an average of 1.8/4 (1—3). The average web angle was 36.5° [20—45], and there was no significant difference with the preoperative web angle (36.1° [15—45]) (p > 0.05 [t-test]).

Preoperative hyperextension of the MCP was found in 21 cases (42%) with an average value of 26° (10—45). Postoperative MCP hyperextension was found in 36 cases (72%), with an average value of 26° (5—50). Patients whose postoperative hyperextension had worsened had a significantly greater loss of TH (p = 0.024 [t-test]). Ten patients had preoperative hyperextension of the MCP greater or equal to 30° which remained postoperatively. The loss of TH in these 10 patients was not greater than that in the rest of the population (p = 0.94 [t-test]).

Average strength was 97% of the contralateral side on the Jamar dynamometer (72—125) and 88% (38—136) with the key pinch.

The average delay to union was 7 months (2—24), and from a subjective point of view, 49 patients (96%) were satisfied or very satisfied with the results and ready to repeat the intervention. A subjective deterioration was noted in six cases. In five, this included pain during inhabitual and repeated efforts. We performed the only reoperation of the series in one patient because of invalidating and permanent pain and loss of strength, without collapse of the trapezial space. This included a scaphometacarpal arthrodesis with bone graft interposition. For this reason, the clinical results of this patient were excluded from the statistical analysis of grip results. In the last follow-up, this patient still had significant pain rated as 6/10 on the VAS and stage 4 of Alnot’s classification. Mobility was: opposition 6/10, counter-opposition 0/4, web angle 15° with 40° MCP hyperextension. The patient was not satisfied with the results and was not ready to repeat the intervention.

Plain X-ray results

The loss of TH was constant and found in all patients. The average TH at 1 year was 66% (31—100). At the last follow-up, the average TH was 50% (0—85) of the initial TH.

Hand function

Hand function in 21 of the patients (42%) were considered average or poor. The average hand function score was 17.2/20 (4—20). The results of the 5 types of grips are summarized in Table 1. The results of the spherical grip were significantly worse than the four other grips (p < 0.05 [MWT]).

The results of the statistical study of the different factors that could influence hand function are summarized in Table 4. We found several factors significantly associated with less good subjective hand function.
Table 4 Evaluation of different criteria affecting hand function.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Grip score ≤ 16</th>
<th>Grip score &gt; 16</th>
<th>p</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56.5 [41.9–75.4]</td>
<td>64.6 [49–77]</td>
<td>0.002</td>
<td>t-test</td>
</tr>
<tr>
<td>Postoperative pain</td>
<td>Yes</td>
<td>Yes</td>
<td>0.037</td>
<td>FET</td>
</tr>
<tr>
<td>(12)</td>
<td>No</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP Hyperextension</td>
<td>Yes</td>
<td>Yes</td>
<td>0.02</td>
<td>FET</td>
</tr>
<tr>
<td>(19)</td>
<td>No</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperextension</td>
<td>35.5° [10–50]</td>
<td>18.5° [10–45]</td>
<td>0.0002</td>
<td>t-test</td>
</tr>
<tr>
<td>Web angle</td>
<td>32.6° [20–45]</td>
<td>39.1° [30–45]</td>
<td>&lt; 0.0001</td>
<td>t-test</td>
</tr>
<tr>
<td>Trapezial index</td>
<td>41.86% [0–68]</td>
<td>55.62% [26–85]</td>
<td>0.006</td>
<td>t-test</td>
</tr>
<tr>
<td>Rel strength key</td>
<td>90.1% [38–160]</td>
<td>99.5% [79–128]</td>
<td>0.1</td>
<td>t-test</td>
</tr>
<tr>
<td>Rel strength Jam</td>
<td>95.6% [25–145]</td>
<td>95.9% [66–136]</td>
<td>0.66</td>
<td>MWT</td>
</tr>
<tr>
<td>Initial Comtet stage</td>
<td>1</td>
<td>4</td>
<td>0.09</td>
<td>Khi²</td>
</tr>
<tr>
<td>Retro-Kapandji test</td>
<td>9.4 [6–10]</td>
<td>9.8 [8–10]</td>
<td>0.23</td>
<td>MWT</td>
</tr>
<tr>
<td>Postoperative complications</td>
<td>Yes</td>
<td>No</td>
<td>0.14</td>
<td>FET</td>
</tr>
<tr>
<td>Operated side</td>
<td>Dominant</td>
<td>Non dominant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results of the statistical analysis of different criteria that could influence hand function. Web angle: web space angle or abduction; trapezial index at the last follow-up is expressed as a percentage of the preoperative trapezial index. Rel Strength: relative strength expressed as a percentage of the strength of the contralateral hand.

- Age, the patients were younger, 56 years old versus 64 years old (p = 0.002).
- Postoperative pain, the patients were more often in pain (p = 0.037).
- More important trapezial space collapse, the TI was 41.85% versus 55.6% of the initial TI (p = 0.006).
- Smaller postoperative web angle, 32° versus 39° with a p = 0.0001. The 14 patients with a postoperative web angle less or equal to 30° had statistically poorer grip results (p = 0.0008 [MWT]).
- Postoperative MCP hyperextension was more frequent and important, 35.5° versus 18.5° (p = 0.0002). More than 50% of the patients with postoperative hyperextension greater or equal to 30° had preoperative hyperextension and the 10 patients with preoperative MCP hyperextension of greater or equal to 30° still had it postoperatively.

Patients with a web angle of less or equal to 30° had a significantly lower hand function score than the other patients (14.3/20 versus 18.3/20 [p = 0.0003 [MWT]]). In the same way, the patients with postoperative MCP hyperextension greater or equal to 30° had worse hand function (14.9 versus 18.6 [p = 0.0001 [MWT]])

Discussion

Because of the key role of the thumb column in pollicidigital grips, we evaluated hand function at the follow-up of our patients. Our results identified several prognostic factors for hand function following trapeziectomy and ligament reconstruction with tendon suspension.

Like other authors [3,7–9], this series showed that the results of spherical grips (screwing and unscrewing a cover) were significantly poorer in these patients. Indeed, to be successful, complete restoration of the thumb-index web space, recovery of strength and a stable thumb column at the level of neo-trapeziometacarpal but also of the MCP joint are necessary.

The study of five basic grips, which are used on everyday movements, identified five bad prognostic factors for hand function: young age, the presence of postoperative pain, postoperative web angle less or equal to 30°, postoperative hyperextension of the MCP greater or equal to 30° and Trapeziometacarpal space collapse.

The subjective nature of our assessment provided by patients, with no quantifiable objective criteria, explains the poorer results in younger patients. Indeed, these patients expect more from the daily use of their hand.

As Apard and Saint-Cast [20] have also emphasized, pain especially occurs during grips that require strength. This pain causes difficulty or anxiety about performing these movements.

A good thumb-index web angle is necessary when grasping all types of objects, in particular for spherical and pinching grips. Any loss of amplitude affects these grips. Our goal when performing a trapeziectomy is to obtain a web angle of at least 40°. We are also careful to use postoperative casts that do not artificially widen the web angle by hyperextension of the MCP.

A stable thumb column is necessary for a strong pollicidigital grip, but also for precision grips. We consider hyperextension of the MCP to be one of the elements of a lax thumb column. This hyperextension of the MCP makes it especially difficult to perform grips such as the key pinch and spherical grips. Indeed, during these grips, pollicidigital opposition can be performed easily, but when force must be
applied to this pinch, MCP hyperextension suddenly occurs resulting in a type of springing back of the MCP. This springing action is associated with a loss of strength and grip precision (Fig. 2). Based on these results, like other authors [4,21], we now systematically correct preoperative MCP hyperextension greater or equal to 30°. An anterior capsulodesis of the MCP is performed by reattaching the sesamoids to the anterior part of the first metacarpal neck with a bone anchor. Once again, we must emphasize the importance of having a cast which creates slight flexion of the MCP.

Loss of height of the trapezial space also negatively affects grip. In fact, this is probably in part due to the development of hyperextension of the MCP and the reduction in web space which develops with trapezial space collapse; similar to what occurs during early development of osteoarthritis of the trapeziometacarpal joint (Fig. 3). Preserving TH should help avoid this. For the moment, no ligament reconstruction technique has been shown to be better than another for this purpose [3,22]. Nevertheless, the question of the role of trapezial implants should be considered to preserve the length of the thumb column. The recent series by Condamine et al. [23], with a resurfacing metacarpal implant, is interesting because the results for pain, mobility and strength are good. In their series with nearly 5 years of follow-up, no secondary operations were necessary and there were few complications from the implants (five implants subsided with no clinical consequences). Forty percent of the patients in the Condamine et al. study were working. It might therefore be interesting to offer this alternative to certain working patients who wish to go back to work, knowing that a trapeziectomy could still be performed in case of failure. For the purpose of maintaining TH, a partial trapeziectomy could also be an alternative in younger patients. The clinical results of this technique are also good [21] and theoretically it should preserve TH better over time. However, in the study by Menon [21], four reoperations for total trapeziectomy were unfortunately necessary out of 32 because of pain from undiagnosed peritrapezial osteoarthritis. Total trapeziometacarpal prostheses also preserve the length of the thumb column. However, the rate of complications, and reoperations [20] in the series of total prostheses compared to our series and to the series of trapeziectomies with ligament reconstruction in the literature, suggest that care should be taken in the indications for this type of implant.

Evaluation of hand function has rarely been performed in the literature, because most authors simply perform the classic evaluation of pain, mobility and strength. Certain authors [3,5,8,9] have evaluated postoperative hand function including different questions about everyday movements (using a coin, holding a can, turning a key, knitting, writing, unscrewing a top, buttoning a shirt, brushing your teeth). However, none of these studies evaluated global hand function, they gave the number of patients who had good results for each type of grip, which was usually approximately 80%. Trumble et al. [24] analysed the exact results of DASH questions to specifically evaluate grip. Belcher and Nicholl [25] used the ADL [14] questionnaire and obtained a postoperative score of 5.1 out of 30 compared to 8.1 preoperatively although the authors did not provide details on the difficulties encountered by each patient. Kaarela and Raatikainen [7] reported 71% good and excellent results in performing everyday movements but did not provide any further details. Aparid and Saint-Cast [20] used a detailed and interesting questionnaire during follow-up of a series of trapeziometacarpal prostheses, but did not provide detailed results for each question. Eight out of 25 patients had difficulty performing precise movements and 10 had pain when performing power grips, so they avoided them.

It is essential to develop a standardized method to evaluate hand function hand grip to compare the different clinical series, whose results for pain, mobility and strength are so close. The Nelson Hospital Score, which has been described before our study by Citron et al. [26], is interesting and should be adopted for general use as a tool to...
assess hand function and compare future interesting series of osteoarthritis of the trapeziometacarpal thumb joint.

Moreover, the results of our series, with more than 90% of patients satisfied and with good results for pain, are comparable to those in the literature [2–7,27]. Our patients also recovered good mobility of the thumb column. Recovery of strength, which is probably the criteria with the least satisfactory results in our study, was worse for key pinch than for grasping. Patients who underwent bilateral interventions, and the numerous patients with symptoms in the contralateral hand, create a bias when measuring strength because of the comparison with the contralateral side. Because certain files are quite old, preoperative strength measurements could not always be obtained. Results in series with at least 5 years of follow-up [2,7,27] show, like ours, clinically stable results over time with very few reoperations.

References