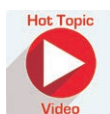


Autologous Fat Transfer for Thumb Carpometacarpal Joint Osteoarthritis: A Prospective Study

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Background: Most operations for carpometacarpal joint osteoarthritis of the thumb irreversibly alter or destroy the anatomy. There is a high demand for minimally invasive alternatives. The authors report the results of autologous fat transfer for treatment of thumb carpometacarpal joint osteoarthritis.

Methods: In a prospective study, 50 patients with thumb carpometacarpal joint osteoarthritis were observed for 1 year after autologous fat transfer. Manual liposuction and centrifugation were performed. Pain rating according to visual analogue pain scale; objective force of pinch grip and fist closure; and Disabilities of the Arm, Shoulder, and Hand questionnaire scores before and after treatment were analyzed.

Results: The average pain in stage 2 patients preoperatively was 7.7 ± 1.3 ; it was 1.8 ± 1.9 after 6 months and 2.4 ± 3.1 after 12 months. Patients with stage 2 osteoarthritis demonstrated a superior benefit from this treatment compared with patients with either stage 3 or stage 4 thumb carpometacarpal joint osteoarthritis. There were similar improvements for the parameters strength and Disabilities of the Arm, Shoulder, and Hand questionnaire score. No serious adverse events were observed.

Conclusions: Autologous fat transplantation is an appealing alternative, especially in early-stage basal joint osteoarthritis of the thumb. The low invasiveness of the procedure and early recovery of patients compared with classical procedures such as trapeziectomy, and the superior long-term results compared with classical injection therapy, make this approach feasible as a first-line therapy in early-stage basal joint osteoarthritis of the thumb. (*Plast. Reconstr. Surg.* 140: 327, 2017.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Thumb carpometacarpal joint osteoarthritis is a common problem, with up to 25 percent of postmenopausal women being affected.¹ Various conservative and surgical options have been described. These include conservative measures such as corticoid² or hyaluronic acid injections³ and surgical interventions such as metacarpal extension osteotomies, trapeziectomies

alone, or in combination with various interposition arthroplasties and basal joint prosthetics.² Interposition procedures using a variety of autologous and nonautologous options such as dermal matrices,⁴ spacers,⁵ and costochondral grafts⁶ are similarly promoted and advocated.

Operative treatments have been shown to yield high satisfaction rates, approaching 95 percent of

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A “Hot Topic Video” by Editor-in-Chief Rod J. Rohrich, M.D., accompanies this article. Go to PRSJournal.com and click on “Plastic Surgery Hot Topics” in the “Digital Media” tab to watch. On the iPad, tap on the Hot Topics icon.

patients in some studies.² Nevertheless, it is important to appreciate that most surgical techniques irreversibly destroy the anatomy of the basal joint of the thumb, which is of minor concern in stages 3 and 4, where the joint is already destroyed in most cases anyway, but meaningful in painful stage 2 osteoarthritis of the basal joint of the thumb.

Shortening of the thumb, metacarpal subsidence after trapeziectomy, and prosthetic dislocation are recognized complications after classic thumb carpometacarpal joint osteoarthritis surgery.² Most techniques advocate splinting for several weeks, with even longer periods of subsequent physiotherapy. In a study by Hohendorff et al.⁷ examining trapeziectomy with flexor carpi radialis interposition in stage 2 to 4 thumb carpometacarpal joint osteoarthritis, according to the Eaton classification,⁸ patients on average demonstrated an inability to work of 16 weeks in craftsmen and 12 weeks in housewives.⁷ The availability of a less invasive alternative that would not result in protracted periods of time off work, and that would obviate the main concerns of patients with thumb carpometacarpal joint osteoarthritis, should prove appealing, especially as most patients would prefer to avoid trapeziectomy as their first surgical intervention.

Autologous fat may serve as a buffer in the arthrotic joint. A high stem cell count and the ability of adipose-derived stem cells to differentiate into chondrocytes has been demonstrated in lipoaspirate.^{9,10} Several studies have demonstrated both antiinflammatory and chondroprotective effects of adipose-derived stem cells.¹¹ Furthermore, these cells have been able to regenerate cartilage in experimental settings.¹² Chondrocytes in turn are able to promote differentiation of adipose-derived stem cells,¹² further bolstering a potential therapeutic role of adipose-derived stem cells in the treatment of osteoarthritis.

In our study, we hypothesized that autologous fat grafts, naturally containing adipose-derived stem cells, can provide an additional viscosupplementary and interpositional effect that may reduce pain in an arthrotic joint. The primary concerns of patients with thumb carpometacarpal joint osteoarthritis (i.e., pain, loss of strength, and impaired hand function) were analyzed in this study. The preliminary short-term results of five patients after fat transplantation to the basal joint of the thumb were promising.¹³

PATIENTS AND METHODS

Institutional review board approval to study intraarticular injection of autologous fat

transplants in patients with thumb carpometacarpal joint osteoarthritis was secured in advance of the study. Only patients that failed conservative treatment (i.e., physical therapy, splinting, pain medication, and steroid and/or hyaluronic acid injections), defined as persistent pain not adequately controlled and that would have been otherwise treated by trapeziectomy, were included. Patients that had previously been treated by surgical therapies were excluded from this study.

In this article, we report on a prospective study of 50 patients, 38 women and 12 men, with an average age of 59.9 years (range, 44 to 83 years) that were treated between July of 2013 and March of 2015 (Table 1). This was designed as a pilot study without a specified control group, and as such the number of patients was not calculated statistically in advance to establish the requisite number of patients to obtain a significant result for a two-point visual analogue pain scale pain reduction. All patients underwent identical treatment. According to the Eaton classification,⁸ 25 patients were stage 2, 18 patients were stage 3, and seven patients were stage 4. All operations were performed using a standard Klein tumescent solution (1000 cc of lactated Ringer solution, 10 cc of sodium bicarbonate 12.5%, 1 cc of epinephrine, and 40 cc of lidocaine). Subcutaneous local anesthesia was administered before stab incision for both liposuction and joint injection.

Fat harvesting and fat processing were performed using the Coleman technique.¹⁴ Fat was aspirated from the abdomen and thighs using a Coleman no. 1 aspiration cannula. After centrifugation (for 3 minutes at 920 g) intraarticular injection of 1 cc of lipoaspirate was performed under radiographic control (Figs. 1 and 2). Light axial traction of the thumb proved particularly helpful in opening the joint space when introducing the blunt 18-gauge needle. Stab incisions were closed with Steri-Strip (3M, St. Paul, Minn.) dressings and a padded dorsal splint administered for

Table 1. Demographic Data

Characteristic	Value
No.	50
Age, yr	
Average	59.9
Range	44–83
Sex	
Female	38
Male	12
Stage	
2	25
3	18
4	7

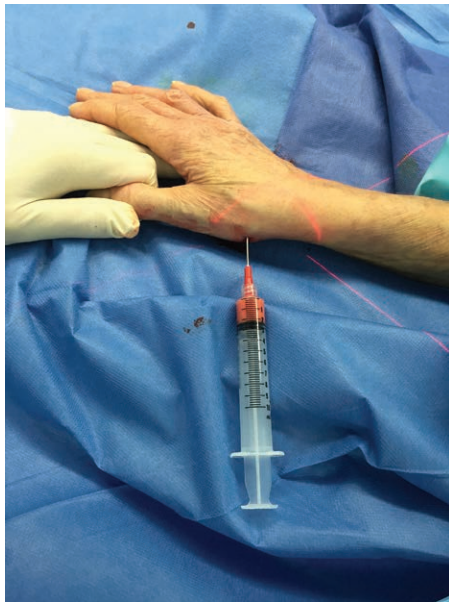


Fig. 1. A 10-cc Luer-Lock cannula and an 18-gauge needle are being used for infiltration of a 1-cc fat transplant into the basal joint of the thumb. Axial traction is being applied to the thumb.



Fig. 2. Radiography is helpful to verify the correct placement of the needle.

7 days. Resumption of work and normal use of the hand that was operated on was allowed directly after splint removal.

All patients were followed for 1 year; intermediate follow-up appointments were arranged at 2 and 4 weeks after the procedure and at 3 and 6 months. No patients received postoperative physiotherapy.

Parameters monitored included the following: (1) subjective pain rating according to the

visual analogue pain scale before and after treatment; (2) objective force of pinch grip and fist closure before and after treatment; (3) mobility of the thumb according to the Kapandji scale¹⁵ before and after treatment; and (4) Disabilities of the Arm, Shoulder, and Hand questionnaire scores before and after treatment. According to the study protocol, the first 20 patients received routine control radiographs at 3 months. Based on radiation hygiene and uneventful results (no additional calcifications because of fat transplantation, no further joint degeneration, just the expected widening of the joint space) noted in all of the first group of 20 patients, the posttreatment radiographic protocol was abandoned for the consecutive patients of the study. Three patients did not respond sufficiently to fat transplantation and were both noted and excluded from the completion of the study protocol, as they required additional surgery to resolve their symptoms.

Statistical analysis was performed using IBM SPSS Version 23 (IBM Corp., Armonk, N.Y.), and *t* tests, a pairwise post hoc test, a Wilcoxon test, and an analysis of variance test were performed. A value of $p < 0.05$ was considered statistically significant.

RESULTS

Patients were monitored closely according to the aforementioned follow-up schedule. No patient reported worsening of symptoms. There were no postoperative complications, no infections, and no significant adverse reactions or side effects noted. Two patients reported a transient paraesthesia of branches of the superficial radial nerve that completely resolved after 2 months. Three patients did not relate sufficient pain relief after the procedure and as such underwent additional surgical treatment; they were excluded from the completion of the study protocol (two patients received thumb carpometacarpal joint denervation 6 months after fat transplantation; and one patient underwent thumb carpometacarpal joint denervation at 3 months and subsequently a trapeziectomy 6 months after fat transplantation, again without substantial improvement of his pain).

Analyzing pain reduction, patients with stage 2 thumb carpometacarpal joint osteoarthritis demonstrated a superior benefit from this treatment compared with patients with either stage 3 or stage 4 thumb carpometacarpal joint osteoarthritis. The average preoperative pain at stress (powerful pinch grip, e.g., opening a screw cap) in stage 2 patients was 7.7 ± 1.3 preoperatively, 1.8 ± 1.9 at 6 months, and 2.4 ± 3.1 at 12 months. The average

preoperative pain at rest in stage 2 patients was 3.5 ± 2.8 preoperatively, 0.4 ± 0.9 at 6 months, and 1.0 ± 2.1 at 12 months. The average preoperative pain at stress in stage 3 patients was 7.6 ± 1.7 preoperatively, 5.0 ± 2.3 at 6 months, and 5.6 ± 2.5 at 12 months after the procedure. The average preoperative pain at rest in stage 3 patients was 2.4 ± 3.0 preoperatively, 1.6 ± 2.6 at 6 months, and 1.8 ± 2.8 at 12 months. In stage 4 patients, the results were less favorable: preoperative pain at stress was 8.9 ± 0.7 preoperatively, 5.0 ± 2.9 at 6 months, and 6.0 ± 3.5 at 12 months. The average preoperative pain at rest in stage 4 patients was 3.7 ± 3.3 preoperatively, 2.3 ± 3.7 at 6 months, and 3.0 ± 3.7 at 12 months. See Figure 3 (pain at stress) for further data. Analyzing all patients together (with stage 2, 3, and 4 thumb carpometacarpal joint osteoarthritis), the patients had significantly less pain at all postoperative time points in comparison with the preoperative situation independent of the stage ($p < 0.05$).

Analyzing the subgroups separately with a Wilcoxon test (the subgroups were too small for the *t* test) in stage 2 and 3 patients, the results for pain

were significantly better at all time points after surgery, but not in stage 4 patients. In stages 2 and 3 of the disease, grip strength improved after fat transplantation. In stage 2 patients, average grip strength for fist closure was 0.4 ± 0.2 bar preoperatively, 0.5 ± 0.2 bar at 6 months, and 0.6 ± 0.2 bar at 12 months. In stage 3 patients, average grip strength for fist closure was 0.4 ± 0.2 bar preoperatively, 0.5 ± 0.2 bar at 6 months, and 0.5 ± 0.2 bar at 12 months. In stage 4 patients, average grip strength for fist closure was 0.3 ± 0.2 bar preoperatively, 0.3 ± 0.2 bar at 6 months, and 0.3 ± 0.2 bar at 12 months. Additional data are provided in Figure 4.

The results for pinch grip were similar. In stage 2 patients, average pinch grip strength was 0.3 ± 0.1 bar preoperatively, 0.4 ± 0.1 bar at 6 months, and 0.5 ± 0.1 bar at 12 months. In stage 3 patients, average pinch grip strength was 0.3 ± 0.1 bar preoperatively, 0.4 ± 0.2 bar at 6 months, and 0.4 ± 0.2 bar at 12 months. In stage 4 patients, average pinch grip strength was 0.2 ± 0.1 bar preoperatively, 0.3 ± 0.1 bar at 6 months, and 0.3 ± 0.1 bar at 12 months. Additional data are provided

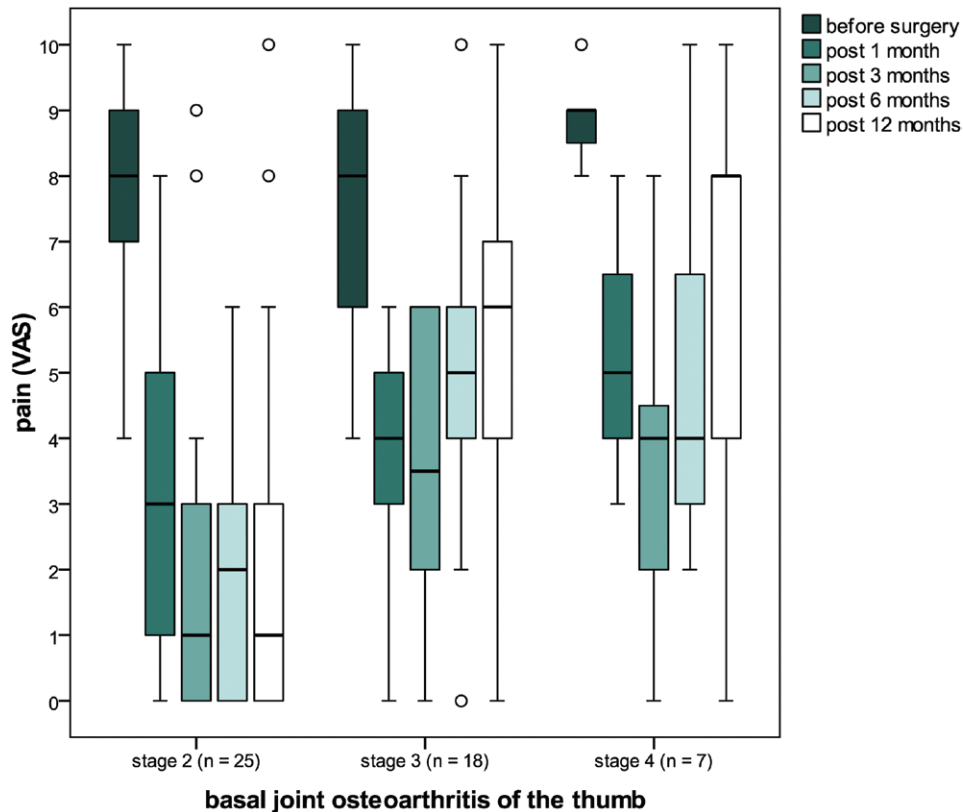


Fig. 3. Pain according to visual analogue pain scale (0 to 10) at stress preoperatively and postoperatively. Radiologic stages 2, 3, and 4 are compared at time points before and at 1, 3, 6, and 12 months postoperatively. The *box plots* present the median, the 25 percent and 75 percent quartile, and the minimum and maximum.

in Figure 5. Analyzing all patients together (with stage 2, 3, and 4 thumb carpometacarpal joint osteoarthritis), the patients had significantly more force and pinch force at all postoperative time points compared with the preoperative situation independent of the stage ($p < 0.05$).

Analyzing the subgroups separately with a Wilcoxon test in stage 2 patients, the results for force and pinch force were significantly better at all time points after surgery, but not in stage 4 patients. In stage 3 patients, the results were only at some time points significantly better.

Disabilities of the Arm, Shoulder, and Hand questionnaire scores improved accordingly. In stage 2 patients, the score improved from 47 ± 14 preoperatively to 17 ± 12 at 6 months and 19 ± 16 at 12 months. In stage 3 patients, the score improved from 50 ± 20 preoperatively to 38 ± 23 at 6 months and 40 ± 24 at 12 months. In stage 4 patients, it improved from 57 ± 23 preoperatively to 41 ± 27 at 6 months and 51 ± 31 at 12 months. Figure 6 demonstrates the scores both preoperatively and postoperatively. Analyzing patients with stage 2, 3, and 4 thumb carpometacarpal joint

osteoarthritis together, patients had significantly better scores at all postoperative time points compared with the preoperative situation independent of the stage ($p < 0.05$). Analyzing the subgroups separately with a Wilcoxon test in stage 2 patients, the Disabilities of the Arm, Shoulder, and Hand score was significantly better at all time points after surgery, but not in stage 4 patients. In stage 3 patients, the results were only significantly better at 1 and 3 months after surgery.

DISCUSSION

The aim of this study was to evaluate the efficacy of a new surgical alternative for the treatment of thumb carpometacarpal joint osteoarthritis. We could demonstrate a significant reduction in both pain and improved overall function as measured by Disabilities of the Arm, Shoulder, and Hand questionnaire score in patients with stage 2, 3, and 4 thumb carpometacarpal joint osteoarthritis. Nevertheless, in patients with higher grades of thumb carpometacarpal joint osteoarthritis, no such impressive clinical benefit was observed

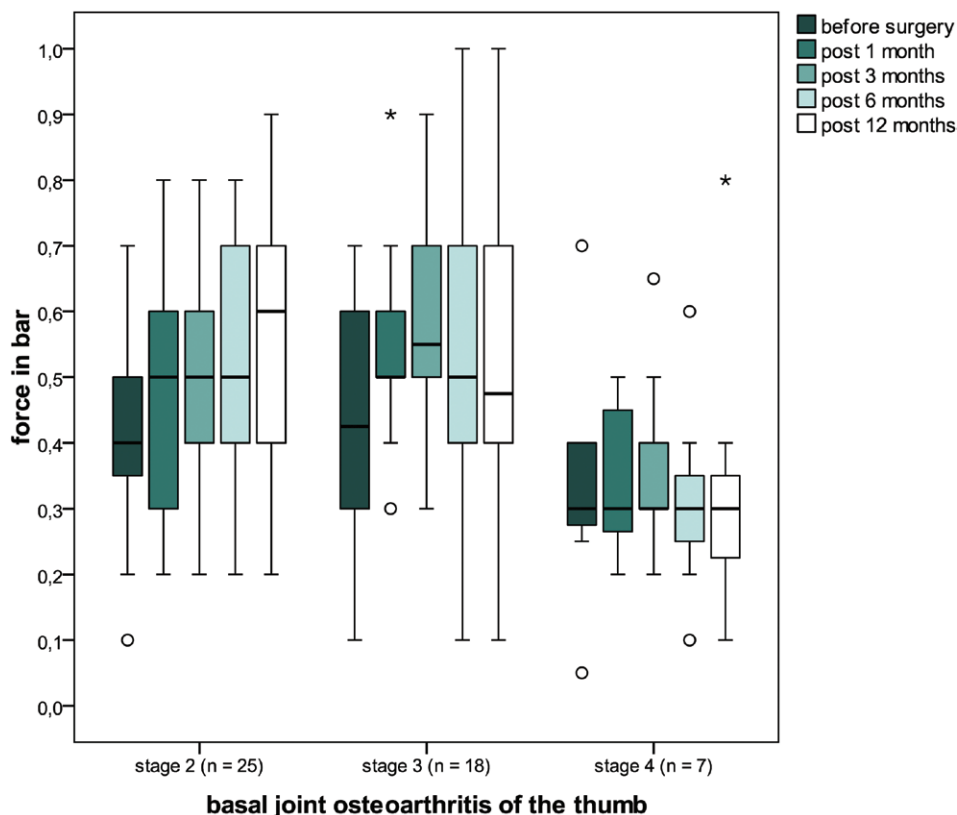


Fig. 4. Grip strength for fist closure preoperatively and postoperatively. Radiologic stages 2, 3, and 4 are compared at time points before and 1, 3, 6, and 12 months postoperatively. The box plots present the median, the 25 percent and 75 percent quartiles, and the minimum and maximum.

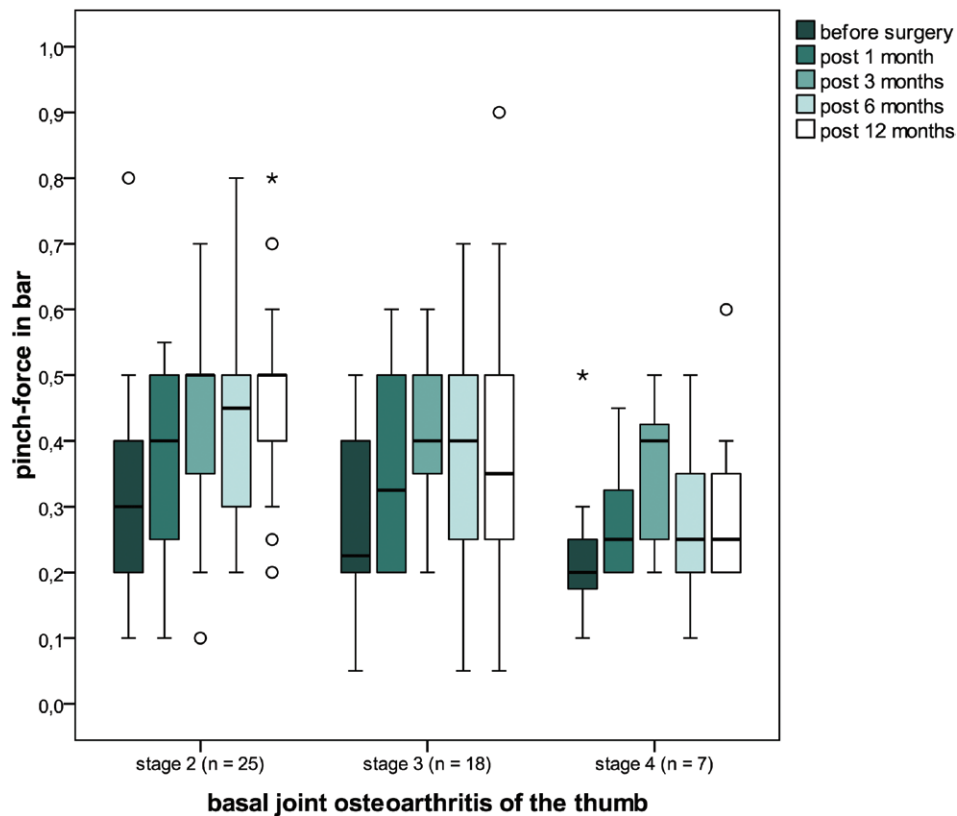


Fig. 5. Pinch grip strength preoperatively and postoperatively. Radiologic stages 2, 3, and 4 are compared at time points before and 1, 3, 6, and 12 months postoperatively. The *box plots* present the median, the 25 percent and 75 percent quartiles, and the minimum and maximum.

as in patients with stage 2 disease. These latter results are not unexpected, as the fat graft does not address advanced subluxation of the basal joint of the thumb or the severe bony destruction. In these patients, simple interposition of the joint space will not sufficiently address the instability and subluxation, and only short-term relief is possible, as our data demonstrate.

The favorable results in stage 2 osteoarthritis may be explained in two ways. Primarily, we propose an immediate buffering effect of the fat transplant as with any other autologous or heterologous interposition. We do not know whether fat cells are surviving within the joint. Pressures attained within the carpometacarpal joint with use far surpass the bursting strength of liposomes. Although injecting fat may be improving the viscoelasticity of the carpometacarpal joint fluid, it is not very likely that fat cells are surviving. Nevertheless, it is interesting to note that a case series of fat transplantation to the temporomandibular joint following removal of a failed alloplastic prosthesis revealed excellent long-term clinical results and documented long-term retention by computed tomographic scan at 5 years.¹⁶ A secondary effect

may be exerted by the co-transplanted adipose-derived stem cells. Experimental observations revealed long-term engraftment of adipose-derived stem cells in the joints of mice, at least 6 months after intraarticular injection.¹⁷ In a degenerative situation with apoptosis of joint cartilage, the activation of chondroblastic differentiation is possible, and documentation of the chondroblastic potential of adipose-derived stem cells is well recorded in the literature.^{10,18} Recent works concerning cartilage protection¹⁹ and regeneration through adipose-derived stem cells underline this hypothesis.^{12,17} However, the extrapolation of regenerating chondrocytes is to be discussed because it is quite impractical that the injection of fat cells alone into a carpometacarpal joint can regenerate chondrocytes that have worn out in stage 3 and 4 conditions. This might be a reason for the higher success in stage 2 basal joint osteoarthritis patients.

Michalek et al.,²⁰ in a case control study, injected freshly isolated autologous stromal vascular fraction cells in patients with stage 2 to 4 degenerative osteoarthritis in a total of 1856 joints, mainly knee and hip joints. Pain, nonsteroidal

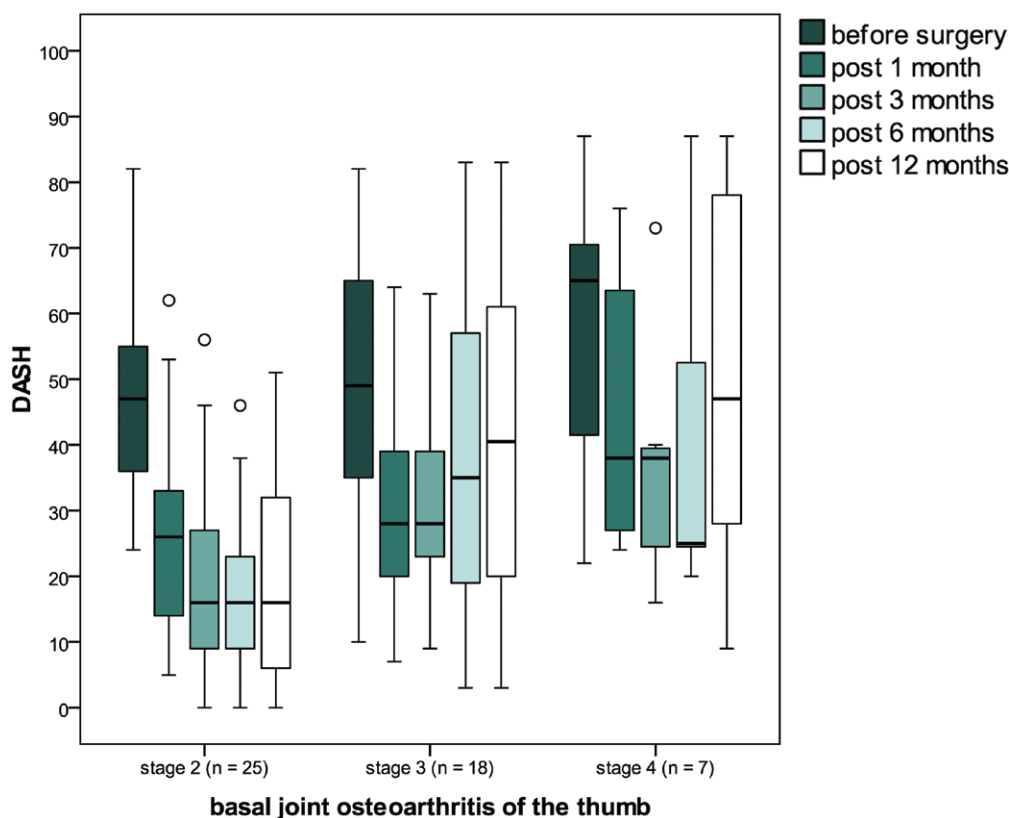


Fig. 6. DASH scores preoperatively and postoperatively. Radiologic stages 2, 3, and 4 are compared at time points before and at 1, 3, 6, and 12 months postoperatively. The *box plots* present the median, the 25 percent and 75 percent quartiles, and the minimum and maximum.

analgesic use, limping, extent of joint movement, and stiffness were evaluated before and at 3, 6, and 12 months after treatment by modified Knee Injury and Osteoarthritis Outcome Score/Hip Disability and Osteoarthritis Outcome Score. The authors report no serious side effects, systemic infections, or malignancy associated with stromal vascular fraction cell therapy, and in 91 percent of patients, a 50 percent score improvement at 12 months was noted after stromal vascular fraction cell therapy.²⁰ In this context, it remains to be seen whether pure adipose-derived stem cell grafts would generate better clinical results than a plain fat graft tested in our study. Unfortunately, it is ethically impossible to perform biopsy of the thumb carpometacarpal joint in a patient after these cell therapies; therefore, clinical study endpoints have to be carefully selected. Both the visual analogue pain scale and the Disabilities of the Arm, Shoulder, and Hand questionnaire have been extensively used for evaluation in clinical hand surgery.

In operative treatment (trapeziectomy and capsulodesis) of thumb basal joint osteoarthritis, Schibli-Beer et al.²¹ reported a postoperative mean

Disabilities of the Arm, Shoulder, and Hand score of 29 ± 22 and a pain level of 1.8 ± 2.0 according to the visual analogue pain scale²¹ 27 months after trapeziectomy. Our results in stage 2 patients 1 year after autologous fat transplantation to the thumb basal joint are of a similar range, with a score of 19 ± 16 and a pain level of 2.4 ± 3.1 at stress and 1.0 ± 2.1 at rest.

After the Epping procedure (trapeziectomy with flexor carpi radialis tendon sling stabilizer), Wittemann et al. reported a Disabilities of the Arm, Shoulder, and Hand score of 26 at 34 months after surgery.²² Rab et al.²³ reported postoperative data with a mean score of 29 ± 16 at 31 months after trapeziectomy and flexor carpi radialis suspension, and a mean score of 23 ± 12 for patients with trapeziectomy and abductor pollicis longus suspension. The average pain was 0.9 ± 1.5 and 1.1 ± 1.7 , respectively.²³ Similar pain and Disabilities of the Arm, Shoulder, and Hand levels were recorded in our study after fat arthroplasty alone.

Bahadir et al.²⁴ reported about stage 2 and 3 basal joint osteoarthritis patients and compared the results of a single steroid injection in 20 patients and three weekly injections of hyaluronic

acid in another 20 patients. These authors did not analyze stage 2 and 3 patients separately. The average pain in the steroid group was 5.9 ± 1.6 before treatment and 4.9 ± 2.0 at 12 months after treatment. The average pain in the hyaluronic acid group was 6.5 ± 2.0 before treatment and 6.0 ± 2.1 at 12 months after treatment. Bahadir et al. concluded that both therapies are effective in reducing pain but steroid injections provide a more effective and long-lasting pain relief and that, in the hyaluronic acid group, repeated injections (not only the three basic injections) might be required.²⁴ In comparison with the results after steroid or hyaluronic acid injections, the results of fat injections are superior, with an average pain at stress in stage 2 patients of 7.7 ± 1.3 preoperatively and 2.4 ± 3.1 at 12 months. In stage 3 patients, the average pain at stress was 7.6 ± 1.7 preoperatively and 5.6 ± 2.5 at 12 months. After fat transplantation, even in stage 3 patients, the results are better than in the mixed stage 2 and 3 group after steroid or hyaluronic acid injection.

The placebo effect of any injection is demonstrated in the study by Meenagh et al. They compared steroid injections to saline injections in a control group. Both groups had a benefit from intraarticular injection, but none had a significant reduction of visual analogue pain scale score after 24 weeks.²⁵

It is important to define and acknowledge specific limitations of our study. We did not randomize our novel procedural study with an established control or an alternate standard (e.g., a trapeziectomy or injection therapy). An unnecessary liposuction and infiltration of tumescent solution is ethically difficult to justify. In view of these limitations, study points such as complications, invasiveness, outcome, and patient satisfaction cannot be directly compared. Reflecting on our findings, however, a controlled study of stage 2 thumb carpometacarpal joint osteoarthritis may be warranted. Furthermore, it is important to note that an autologous lipoaspirate cannot be defined biochemically like a classic drug. Biological differences such as the proportion of viable cell yield and the individualized number of adipose-derived stem cells procured from fat grafts obtained from each patient may have an effect on outcome. It is well described that various liposuction techniques offer adipose-derived stem cell-rich fat grafts²⁶ and centrifugation-based technique yield the highest amount of adipose-derived stem cells in the phase of highest density.²⁷ As we consider our approach of fat grafting to the joint as an interposition arthroplasty, the use of modified or further

purified fat grafts is at present not justified. The use of further processed autologous or allogenic grafts by cell sorting, separation, or other invasive techniques to purify a graft or solely sorted adipose-derived stem cells is regulated by the government as advanced cell therapy. Studies in this field are costly and time consuming, making them difficult to institute. The work by Karagianni et al. summarize the challenging legal situation.²⁸

CONCLUSIONS

We conclude that autologous fat transplantation to the basal joint of the thumb is an appealing alternative in early-stage basal joint osteoarthritis of the thumb. The low invasiveness of the procedure and early recovery of patients compared with classic procedures such as trapeziectomy and the superior results compared with published results of steroid or hyaluronic acid injections make this approach feasible as a first-line therapy in early-stage basal joint osteoarthritis of the thumb. The presented results are at least very compelling.

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