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## Jumper's knee treatment with extracorporeal shock wave therapy: a long-term follow-up observational study

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**Aim.** Jumper's knee affects more frequently athletes participating in jumping activities. This pathology is very difficult to treat: various therapeutic treatments are used, often based on the physician's personal experience rather than clinical evidence. The aim of this prospective study is to present our experience with the treatment of jumper's knee using extracorporeal shock wave therapy (ESWT) in a group of patients followed up for 2 years after treatment.

**Methods.** In this study, we included 73 sports patients (83 knees), 54 males and 19 females, aged between 15 and 69 years (mean age: 32 years). All patients underwent clinical and instrumental diagnosis (ultrasonography, magnetic resonance imaging and X-rays) in order to identify presence, location and seriousness of the specific tendinopathy. The symptomatology was classified using the visual analogical scale and according to a 6-stage clinical evaluation range. Shock wave treatment was applied with an electromagnetic shock wave generator. The protocol consisted in an average of 4 sessions (minimum 3, maximum 5), at a 2/7-day interval. In each sessions, 1 500-2 500 impulses were administered with an energy varying between 0.08 and 0.44 mJ/mm<sup>2</sup>.

**Results.** We obtained satisfactory results in 73.5% of cases (54.2% excellent results and 19.3 good results). In performing athletes (16 tendons), treatment was satisfactory in 87.5% of cases, with an average time of resuming sport of approximately 6 weeks.

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All authors certify they not have signed any agreement with a commercial interest related to this study.

The research was carried out in accord with the ethical standards described by the Helsinki Declaration, and was approved by a local Ethical Committee.

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**Conclusion.** The outcome of the described shock wave treatment appears to be satisfactory and confirms the role of this alternative treatment in the management of the tendon disorders.

**KEY WORDS:** Short-wave therapy - Tendinopathy - Patellar ligament - Knee - Physical therapy modalities.

Patellar tendinopathy (Jumper's knee) remains, nowadays, a therapeutic challenge because of the unclear mechanism that induces this condition and related symptoms.

Overloading<sup>1, 2</sup> or incorrect training, hard playing surfaces, and inadequate equipment are implicated as extrinsic risk factors, while age, sex, biotype, internal load, lower limb length discrepancy or abnormality (alignment defects or lower limb rotational defect, foot abnormalities and constitutional laxity) have been considered predisposing factors. Although there's no evidence that any of these factors is determinant in developing patellar tendinopathy, it seems clear that functional overloading, alone or in association with other risk factors, can induce tendon pathology.<sup>3-6</sup>

Since the actual physiopathology is still uncertain, the various types of therapeutic treatments are often based on the physician's personal experience rather than on clinical evidence. A combination of non-oper-

ative measures is often applied, sometimes in association with a period of rest or reduction of heavy activities. Since a comparison with a control group is difficult, the efficacy of each single treatment cannot be easily demonstrated.

However, conservative treatment may heal or keep under control up to 90% of patellar tendinopathy cases, with only 10% of patients being considered for surgery.<sup>2, 7, 8</sup>

The purpose of this type C study (prospective study without a control group, but with adequate analysis and follow-up of sufficient scope and duration)<sup>9</sup> was to evaluate the effectiveness of extracorporeal shock wave therapy (ESWT) on jumper's knee, on the assumption that this therapy would reduce pain and time needed to return to sports.

### Materials and methods

Between September 1998 and August 2005, 102 patients affected by Jumper's knee were treated with ESWT.

Inclusion of patients was discussed with the local Ethical Committee and a randomized placebo-controlled study was not permitted. Lack of a control group for ethical reasons is often found in similar published studies.<sup>10-13</sup>

The study included patients who had a confirmed Jumper's knee diagnosis since at least 3 months, with pain not responding to conservative treatment (medical and physiotherapeutic). Patients who underwent physical therapy in the 4 weeks prior to ESWT were not included in this study (3 patients), as well as those who had taken non steroidal, anti-inflammatory medication the previous week (4 patients). Exclusion criteria also included other associated pathologies, such as polyneuropathies (1 patient), gonarthrosis (1 patient), patellofemoral chondromalacia (9 patients), previous surgical treatments of the knee affected by patellar tendinopathy (7 patients) and patients lost at short-term follow-up (6 patients).

In this study, we included 73 patients (54 males and 19 females), age ranging between 15 and 69 years (mean age: 32 years). All patients were involved in various sports activities: 13 as professionals (18%), 41 as amateurs (56%), and 19 practicing sports occasionally, but at least once a week (26%). A large part of them (54%) were jumping athletes (volleyball and basketball players).

TABLE I.—Classification of jumper's knee according to symptoms (modified Blazina Scale).

Classification	Symptoms
Stage 0	— No pain
Stage 1	— Pain only after intense sports activity: no undue functional impairment
Stage 2	— Pain at the beginning and after sports activity: still able to perform at a satisfactory level
Stage 3	— Pain during sports activity: increasing difficulty in performing at a satisfactory level
Stage 4	— Pain during sports activity: unable to participate in sport at a satisfactory level
Stage 5	— Pain during daily activity: unable to participate in sport at any level

Since 10 patients were affected by bilateral tendinopathy, a total of 83 tendons were treated.

A diagnosis of patellar tendinopathy was made on the basis of the patient's history and physical examination. All patients underwent clinical and instrumental diagnosis (ultrasonography, magnetic resonance imaging and X-rays in standard projections), in order to identify presence, location and severity of the specific tendinopathy, with or without calcific areas.

In our group, the inferior pole of the patella was affected in 67.5% of cases (56 tendons), the distal insertion on the anterior tuberosity of the tibia in 10.8% of cases (9 tendons), whereas the quadriceps tendon was affected in 21.7% of cases (18 tendons).

The X-ray showed calcium deposits in 11 cases: 4 cases regarded the quadriceps tendon, 6 cases the origin of the patellar tendon and 1 case the insertion region.

The pain symptomatology was classified with visual analogical scale (VAS) and with the use of a slightly modified version of the 6-stage classification described by Blazina *et al.*,<sup>14</sup> currently used in clinical setting as reported by some of us in previously published studies<sup>4, 5</sup> (Table I).

Shock wave treatment was applied using an electromagnetic shock wave generator produced by STORZ Medical.

The protocol consisted in an average of 4 sessions (minimum 3, maximum 5), administered with a 2/7-day interval. In each session, 1 500-2 500 impulses were administered. The energy provided varied from the lowest (0.08 mJ/mm<sup>2</sup>) to the highest energy level (0.44 mJ/mm<sup>2</sup>), depending on patient's pain tolerance and the presence of calcifications. Even though treatment was painful, all patients underwent therapy with no form of

TABLE II.—Classification of results.

Results	Classification
Excellent	— Stage 0 at the time of follow-up
Good	— Stage 1 with a post-treatment improvement of at least two stages
Fair	— Improvement but the final result was stage 2 or higher
Poor	— No improvement

systemic or local anesthesia or sedation. In no case, we observed collateral effects caused by therapy.

At the end of treatment, patients were asked not to return to sports activities for a minimum of 3 weeks and not to assume any medical therapy. Complete return to sports activities took place in accordance with the athlete's pain tolerance and the absence of clinical signs.

All patients were evaluated before therapy and at 1 month after the last ESWT session. All patients were assessed and evaluated at short-term (6 to 12 months), 68 patients (77 tendons) at medium-term (13 to 24 months) and 61 patients (69 tendons) at long-term (over 24 months).

Evaluation of post-treatment results was made on the basis of the average VAS score and of the subjective clinical evaluation range. The results were classified with the criteria shown in Table II.<sup>3</sup> In conclusion, excellent plus good results were considered as satisfactory and fair plus poor results as not satisfactory.

*Statistical analysis*

The statistical analysis of the results ( $P < 0.05$ ) has used Student's t-test for parametric variables and Mann-Whitney U and Wilcoxon test for non-parametric variables. SPSS v.13 software package was used for data analysis.

**Results**

The mean values according to the VAS scale were evaluated at different stages and are shown in Figure 1.

A significant average improvement ( $P < 0.01$ ) of the initial pain symptomatology ( $7.1 \pm 2.1$ ) can be observed at 1 month after the end of treatment ( $4.23 \pm 2.4$ ). The mean value of the VAS scale decreases further in patients at short-term ( $3.32 \pm 1.9$ ) and is constant at

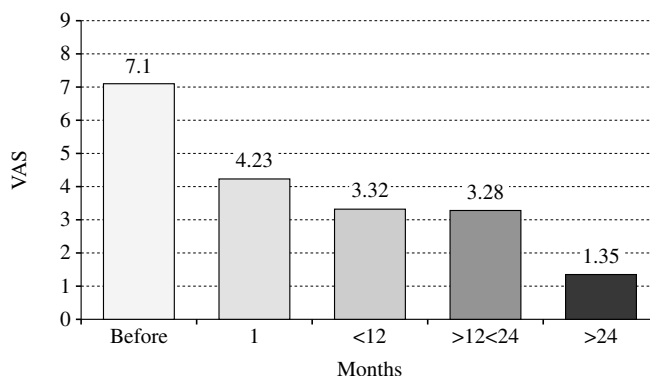


Figure 1.—Mean values according to the visual analogical scale at different stages.

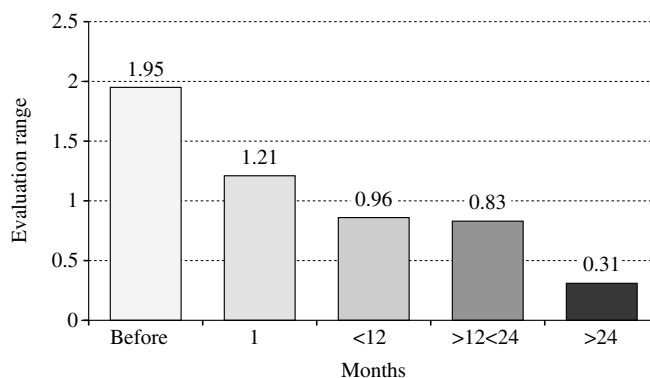


Figure 2.—Mean values using clinical evaluation range at different stages.

medium-term follow-up ( $3.28 \pm 2.3$ ), reaching 1.35 ( $\pm 2.1$ ) 24 months after the last treatment.

Figure 2 shows mean values using subjective clinical evaluation range (Stage 0 through 4) at different stages. A noticeable improvement is shown starting 1 month after the end of treatment (mean:  $1.21 \pm 0.6$ ) ( $P < 0.01$ ) and continuing at short-term evaluation (mean  $0.86 \pm 0.8$ ), while at medium-term follow-up the improvement is unchanged (mean  $0.83 \pm 0.6$ ). At long-term follow-up, patients showed an improved clinical condition even 2 years after the end of the treatment (mean:  $0.31 \pm 0.4$ ).

Finally, we obtained satisfactory results in 43.4% of cases (36 out of 83 tendons) at 1-month follow-up, increasing to 63.9% at short-term follow-up (53 out of 83 tendons), 68.8% at medium-term follow-up (53 out of 77 tendons) and reaching 79.7% in the last evaluation (55 out of 69 tendons) (Table III).

TABLE III.—Results at different follow-ups.

Follow-up	No. of tendons	Satisfactory (%)	Unsatisfactory (%)
1 month	83	43.4	56.6
Short term (2-12 months)	83	63.9	36.1
Medium term (13-24 months)	77	68.8	31.2
Long term (>24 months)	69	79.7	20.3

### Discussion

Conservative treatment of Jumper's knee, calcific or non-calcific, normally includes rest, different kinds of physical therapy and non-steroidal anti-inflammatory medications, including infiltrating therapy. In the last few years, different kinesiotherapeutic treatments, such as femoral quadriceps eccentric exercises,<sup>15-19</sup> echo-guided sclerosing injections into vascular neoformations in tendinosis areas<sup>20-23</sup> and ESWT<sup>24-26</sup> have been proposed in chronic cases and after failure of conventional therapies.

Despite its success in clinical application in the treatment of soft tissues and orthopedic pathologies in the past 10 years, the exact mechanism of ESWT is not yet fully understood. To our knowledge there are only 3 papers regarding patellar tendon pathology and ESWT in international literature.

A recently published study with control group has been conducted on an animal model:<sup>24</sup> the rabbits affected by collagenase-induced patellar tendinopathy were treated with 1 500 impulses at 0.29 mJ/mm<sup>2</sup>. The rabbits were randomly divided into two groups, which were sacrificed at the 4<sup>th</sup> and 16<sup>th</sup> week after ESWT, respectively. Histological examination and mechanical and biochemical tests were then performed. The histological examination demonstrated increased blast-like tenocytes at the 4<sup>th</sup> week, while more mature tenocyte with neovascularization were found at the 16<sup>th</sup> week. The ultimate tensile load in the ESWT tendon increased by 7.03% at 4 weeks and 10.34% at 16 weeks after treatment, as compared to the sham group.

The second study is a randomized controlled trial conducted on 20 tendons.<sup>27</sup> Treatment subjects received 3 to 5 sessions of ESWT, while control subjects received 3 to 5 sessions with the use of an energy-absorbing pad. The effects of the shock wave therapy were measured using the Victorian Institute of Sports

Assessment (VISA) test and a vertical jump test, before treatment and at 5 and 12 weeks after treatment. In their conclusions, the authors affirm that in the first group there were better results compared to those obtained in the sham group for the VISA items 1.3 and 6. Probably the energy level used (0.17 mJ/mm<sup>2</sup>) has a better long term efficacy than higher energy (0.28 mJ/mm<sup>2</sup>), used in previous studies conducted on tendinopathies in other areas.<sup>4, 28</sup>

The last study is a cross-sectional outcome analysis conducted on 28 athletes affected by chronic patellar tendinopathy,<sup>29</sup> that compares results obtained with surgery (13 knees treated by tenotomy) with those obtained with ESWT (15 knees). The protocol for ESWT envisaged three sessions using 1 000 impulses, at a frequency of 4 Hz and an energy flow density of 0.08 mJ/mm<sup>2</sup>. All patients were evaluated with VAS, VISA score and Roles and Maudsley scale.

Satisfactory results were 58% with surgery and 66% with ESWT. Differences between the two groups were not statistically significant ( $P > 0.05$ ). However, compared to the ESWT group, surgically treated patients were able to return to work only after an average of 6.1 weeks, whereas none of the patients who received ESWT experienced any working incapability.

Similar results were obtained comparing our study case with a previous study conducted by our group and published in 2002, evaluating the results of surgical treatment in 38 cases of Jumper's knee with an average follow-up of 8 years.<sup>5</sup> The authors concluded that satisfactory results were obtained in 84.9% of cases, returning to sport activities after an average of 5.5 months. In our study, our successful results at a mean follow-up of 3 years (73.5%) emphasize that shock wave therapy gives the opportunity to regain sports participation in shorter period of time (an average of 1.5 months) without any side effects.

In literature, various protocols have been used as well as number of sessions, impulses and energy levels. In the mentioned studies, the parameters used were different, in particular concerning the energy levels provided. In our clinical practice, we apply shock waves according to the guidelines of the Italian Society of Shock Wave Therapy (Società Italiana Terapia con Onde d'Urto, SITOD) and the variability of energy flux density for patellar tendinopathy (0.08-0.44 mJ/mm<sup>2</sup>) can be referred to some individual parameters of a single patient that we have to consider: degree of tendinopathy, presence of calcifications, and toler-

ance to pain. In this case, it is necessary that focalized ESWT be applied by expert physicians.

In our study, we obtained satisfactory results in 43.4% of treated tendons 1 month after the end of the therapy. The percentage raised up to 79.7% at the last clinical evaluation. Although the different follow-up considered for the third (and last) clinical examination in patients included in this study, satisfactory results were 63.9% at 1 year after treatment, 68.8% at 2 years and 79.7% after more than 2 years. This seems to confirm the circumstance, observed by other authors, that the effects of shock wave treatment seem to be time-dependent, as symptoms continue to improve over 24 months.

In our sports population, we obtained satisfactory results in 63.6% of patients practicing occasional sports, in 73.3% of amateurs and 87.5% of athletes. All patients returned to sports between 30 to 45 days after end of treatment and did not undergo additional treatments.

At F.U., no patient reported a decreased level of sports participation. The best results were observed at medium (13-24 months) and long term (>24 months), 68% and 79%, respectively. The results in athletes are better than in patients practicing sports only occasionally ( $P < 0.05$ ), probably due to the pressure on athletes to return to sport in a shorter time.

Finally, the response to treatment seemed not to be influenced by the presence of calcifications, which did not show any radiological evidence of modification after the treatment.

### Conclusions

In our experience, treatment with ESWT can be considered as a valid therapeutic approach without any adverse effects.

Furthermore, patients that did not respond successfully to more than one cycle of therapy could eventually undergo surgery without any contraindication or without negatively conditioning the results of surgical treatment, because the lower-energy shock waves used for the treatment of tendinopathies did not cause tendon damage.<sup>30, 31</sup>

As mentioned before, limitations of this study are: absence of a control group undergoing a placebo therapy and impossibility to achieve 100% patient recall. At present, this study is continuing with the adoption of a control group undergoing alternative treatment,

focusing also on shock wave related modifications evidenced by diagnostic means.

Despite these limitations, the study showed the positive effect of ESWT in the treatment of the tendinopathy, and the results obtained in our experience are encouraging in the light of the long-lasting improvement of the pain symptomatology reached without collateral effects.

However, a prospective randomized clinical trial with a control group and the standardization of physical and technical treatment parameters seems to be necessary for a classification of ESWT as evidence-based medicine.

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