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Review Article



# Impact of Different Physiotherapeutic Regimes on the Outcome after Knee Lesions and Gonarthrosis

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## Abstract

**Background:** Post-injury or degenerative knee joint pain is one of the most common causes of chronic pain in industrialized countries. It leads not only to a significant reduction in the quality of life and to disability, but also to the need for medical interventions with considerable treatment costs. The 12-months prevalence of work disability is 5-22%. For these patients, effective physiotherapeutic and physical treatment for recovery is very essential.

**Patients & Therapies:** A new therapeutic approach is Sanotaping®, in which standardized physiotherapy is combined with tapes coated with metallized polymers (gold and silver). In the prospective randomized trial 110 patients were grouped according to the following treatment regimes: A – physiotherapy only; B – physiotherapy + taping; C – physiotherapy + Sanotaping®. The 60-minute physiotherapy included standardized physiotherapy, cold thermotherapy, electrotherapy, patella mobilization and isometric/isotonic stretching. All patients were surveyed by regarding subjective efficacy parameters.

**Results:** 107 of 110 patients were enrolled in the study. 75 of them additionally answered the questionnaire. After 12 units the combination of physiotherapy + Sanotaping® (group C) showed a significant pain reduction and a significant improvement of extension and flexion compared to the groups with physiotherapy only or with standard tape. Additionally the patients of group C showed the greatest reduction in swelling.

**Conclusion:** This prospective, randomized study indicated that the early application of physiotherapy is of utmost importance, because the entire physiology is restored and the quality of life is improved. The excellent treatment results of the combined therapy of Sanotaping® and physiotherapy as well as rehabilitative treatments should be emphasized. Its sustainability should be a basis for the implementation of combined treatment with functionally applied, metallized polymers (Sanotaping®) in conservative as well as in pre- and postoperative physiotherapy and rehabilitation.

**Keywords:** Knee injury; Gonarthrosis; Physiotherapeutic complex therapy; Taping; Knee pain; Sanotape

## Abbreviations

ANOVA: Analysis of Variance; BAR: German Federal Working Group for Rehabilitation; CE: Communautés Européenes (European Union); C: Celsius; cm centimeter: fig. figure; HZ: Hertz; kg: Kilogram; min: minutes; NRS: Numerical Rating Scale; Qol: Quality of life; Ref: Rreference; ROM: Range of Motion; STD: Standard Deviation; Tab.: Table; TENS: Transcutaneous Electrical Nerve Stimulation; TU: Ttherapy Units; VAS: Visual Pain Scale; vs: Versus; %: Percent

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## Background

In industrialized nations, a very high number of people suffer from chronic knee pain - either due to degenerative disease (e.g. gonarthritis) or due to the effects of injuries (ruptures of the cruciate ligaments, fractures, etc.) [1]. These not only lead to the need for relapsing medical interventions, which generate considerable treatment costs and even the inability to work. They also are responsible for a significant reduction in the quality of life (QoL) [2]. According to a study from 2014, the 12-months prevalence of work disability caused by chronic knee pain is 5-22% [3].

Chronic knee pain is multifactorial and complex in its genesis. Thus, both the basic functional disorder and morphological disturbance of the musculoskeletal system go hand in hand with psychological and social factors in the development of chronic pain syndromes [2]. For patients with chronic knee pain and injuries of the knee joint, effective physiotherapeutic and physical treatment is very important to enable them to participate easily in social life and restore their ability to work. Thus, the physiotherapeutic interventions applied to pain syndromes of the knee joint are mainly aimed at relieving the pain, promoting blood circulation, maintaining and improving mobility and strengthening the muscles [4]. Especially massages with stretching and friction and easing grips are used to achieve pain relief. A manual transverse and longitudinal stretching of the

ischio-crural muscles is primarily aimed at expanding movement and improving trophism. Mobilization of the patella also helps to restore joint motion and maintain or improve mobility. Isometric strength exercises are intended to additionally strengthen the muscles [4].

In physical therapy for knee joint disorders, cryotherapy is used to reduce pain and edema. Even the transcutaneous electrical nerve stimulation (TENS) led to a stimulation of vibration receptors to also relieve pain [4]. The various physiotherapeutic techniques can also be combined with other factors supporting the healing process. This includes, for example, taping, in which tendons and ligaments are specifically relieved or even activated by pulling. This in turn can be combined with other treatments. These include Sanotape®, a special silver- and gold-coated film which is CE-certified as a medical product [5,6]. For Sanotaping®, not only a hematoma- and edema-reducing effect is postulated, but also a significant reduction of hyperthermia (calor) and erythema (rubor), and thus an immediate reduction of pain (dolor) (Sanotape | doctors and therapists), although a placebo effect cannot be ruled out.

## Patients and Therapies

### Study design

From May 2015 to June 2018, a prospective randomized monocenter study was conducted to compare the treatment results of three different physiotherapeutic treatment approaches in patients with knee joint injuries or degenerative disorders. The study involved patients who introduced themselves with knee joint complaints for medically prescribed physiotherapeutic treatment. The study was approved by the ethics committee of the University of Witten/Herdecke (Ref.: 148/2018). The inclusion and exclusion criteria were deliberately broadly defined in order to obtain a result of the study as close to reality as possible. The only inclusion criteria were defined as the age of consent and an injury or degenerative disorder of the knee joint without further injury to the affected leg. Exclusion criteria were the inability to give consent (e.g. age < 18 years or dementia), lack of consent to the study or withdrawal of consent, paralysis or neurological disorders of the lower extremities, malignant diseases and pregnancy.

After detailed pre-procedural information 120 patients could be included in the study (declaration of consent). They were then prospectively randomized and divided into three groups of equal size. After pseudonymization, each patient received 12 therapy units over the course of the study. After 6 and 12 therapy units, an intermediate examination and a final examination were performed respectively.

The key targets to be determined in the study included the change in circumference of the knee joint, the extent of motion after neutral zero method, as well as the patient's pain data on a visual pain scale of 1 – 10 (VAS). In addition, gender, leading and other diagnosis, height, weight, age, comorbidities and profession of the patients were recorded as secondary target variables, and synergistic disorders were additionally documented (ascending chain). Patients with postoperative scar repair were documented photographically during and at the end of the procedures.

### Physiotherapeutic approaches

The physiotherapeutic therapy approach included a standardized exercise therapy, a 15-minute cryotherapy (12-15°C) and an electrotherapy (TENS). Physiotherapy focused on gait training, patella mobilization, stretching of the ischio-crural, gastrocnemius and leg extensor muscles depending on individual progress, as well as isometric strength exercises and concentric, excentric and isokinetic coordination practices in a standing position. The treatment took 60 minutes for the patients of all groups.

In the three groups, the therapeutic program was as follows:

Group A – The first group of patients with knee joint complaints were treated only with physiotherapy according to the guidelines as part of the above mentioned treatment approach.

Group B – The second group of patients with knee joint complaints received knee taping in addition to the above mentioned physiotherapy. The tape was applied according to a standardized pattern.

Group C – The third group of patients with knee joint complaints received taping with Sanotape® in addition to physiotherapy. The application of Sanotape® was carried out according to a standardized pattern.

### Instructions for private exercises - the "3x8 seconds training program"

For each patient, a special and individual exercise program was designed for home use, which the patient was supposed to carry out independently in order to support the treatment results. These exercises should be carried out twice a day isometrically, eccentrically, concentrically according to isokinetic guidelines in order to release weakened muscles, hardened and non-stretchable muscles, tendons and fasciae and thus restore strength and position. In addition, coordination techniques were included. This specific exercise program was developed in the rehabilitation and physiotherapy according to BAR in cooperation with sports scientists and physiotherapists. Patient data collected over 30 years prove that these specific exercise programs minimize pain relapses. - The patients were strongly recommended to do the home exercises to improve the outcome of the treatment. However, this was not checked - also because of logistical aspects.

### Follow-up visits

An extended physical examination of the patients was performed after 6 respectively 12 therapy units. This included the patients' clinical examination with documentation of the range of motion according to the neutral-zero method [7, 8] as well as the measuring of the circumference of both legs in side comparison and documentation of the patient's subjective well-being. The information on the patients' subjective well-being was provided orally by means of a pain assessment using the numerical rating scale (NRS). The results were documented individually for each patient in a questionnaire specially developed for the study.

### Follow-up monitoring

Six months after completion of the study, the satisfaction of the study participants was assessed by means of questionnaires using rating scales. Each patient received a questionnaire with 13 questions by mail. The questions addressed pain, knee joint motion and quality of life after finishing the treatment. In addition, the completed questionnaire was used to assess subjective satisfaction with the treatment results on a scale of 1 to 10. Finally, it was possible to express criticism or appreciation for the therapy in an anonymous text.

### Statistics

The range of motion was determined in degrees, the circumference in cm, and the patient's evaluation was determined using a rating scale. Mean values and standard deviations were calculated of all parameters. Statistical analysis was performed with the Graph-Pad PRISM program (GraphPad Software, Inc., La Jolla, United States of America) using one-way ANOVA and Tukey's post hoc test.

## Results

### Patient data

Of the 120 patients included, 107 (89.2%) could be evaluated completely. In 59 patients (55.1%), the right knee was affected, in 48 patients (44.9%) the left knee. The mean age was 58.7±16.8 years. The patients had an average weight of 84.7±19.8 kg with an average height of 176.4±10.4 cm. The average calculated BMI in group A of the study was 27.6±5.9, that of group B 27.2±4.2 and that of group C was 26.9±4.5. There were no significant differences between the three treatment groups A-C.

Of the 33 (30.8 %) female and 74 (69.2 %) male study patients, 26 patients (24.3 %) were already retired, seven (6.5 %) were pupils or students and 25 (23.4 %) had a mercantile profession and were not exposed to physical stress at work. A further eight patients (7.5 %) were academics, 17 (15.9 %) had a craft profession, three (2.8%) were working in a health profession and five (4.7 %) were professional sportsmen. No information was provided by 16 patients (14.9 %).

31 of the 107 (28.9 %) participants were treated for gonarthrosis, while 47 patients (43.9 %) suffered from chondropathia patellae. Patellar tip syndrome was the reason for this treatment in 14 patients (13.1 %). Injuries of the ligaments, tendons and menisci were treated in 15 cases (14.0 %).

### Treatment regime-dependent assessment

**Assessment of pain:** At the initial examination before starting physiotherapy, patients in group A reported an average pain of 5.45±1.56 on the visual pain scale, while patients in group B rated an average of 6.21±1.80 and patients in group C 7.16±1.72 (Figure 1a). After 6 therapy units, participants of group A with physiotherapy only rated pain on the pain scale at an average of 4.58±1.74. In group B with additional standardized taping, the pain at that time was on average 5.33±1.66 and in group C with physiotherapy and standardized Sanotaping® only 2.74±1.73. After 12 therapy units, the pain in group A was assessed with 4.10±1.51 points and in group B the average was reduced to 4.56±1.54 (Fig. 1a). In group C the average value was 1.04±1.33.

After 12 therapy units the pain had decreased in group A by an average of 1.34±1.06 scores and in group B by 1.72±0.822 scores on the pain scale. In group C these values had decreased significantly by 6.12±1.60 pain scores.

**Assessment of leg tumescence:** The determination of the leg circumferences in lateral comparison, based on the data in the center of the patella, 20 cm above and 10 cm below it, showed no significant differences between the groups in the interim examination after 6 TU, nor after 12 TU. For the upper

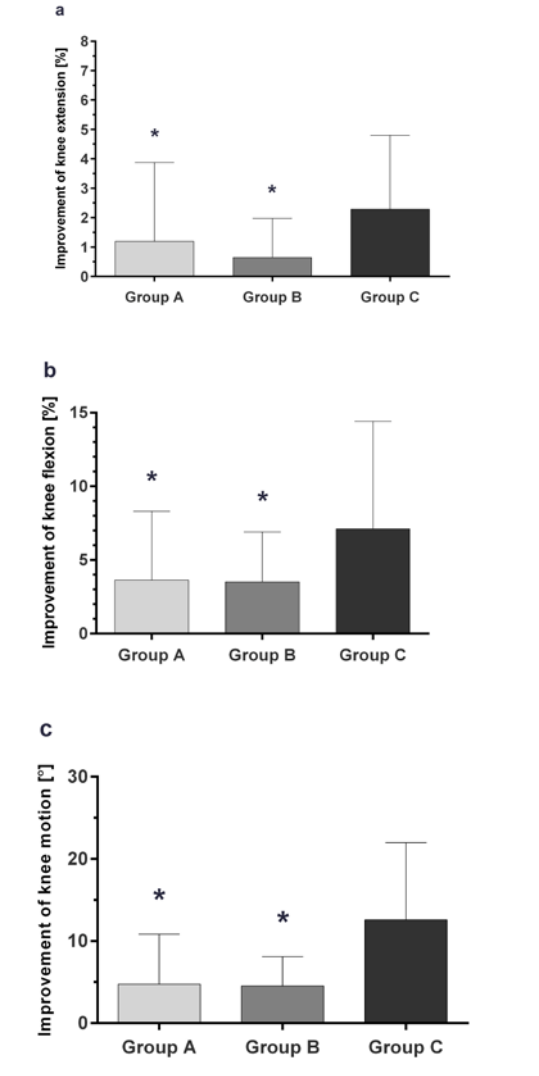


**Figure 1** a Evaluation of patients` pain in the three groups of different physiotherapy regimes: group A - physiotherapy only, group B - physiotherapy+taping, group C - physiotherapy+sanotaping® Degree of pain measured by visual analogue scale (VAS) at the start and after six and twelve therapy units. b Percentage reduction of leg circumference measured at the patella after 12 therapy units. Data expressed as means±STD; *p<0.01 vs. group C.

leg measurement, there was a change in circumference in group A of -0.22±1.32cm (0.04±1.45%) from 48.57±9.28cm to 48.35±8.93cm, in group B by +0.08±0.65cm from 51.32±6.24cm to 52.24±6.28cm, corresponding to an increase of 0.42±1.09%, and in Group C an increase of 0.12±0.43cm (0.23±1.88%) from 50.62±7.58cm to 50.74±50.74cm.

For the lower leg circumference assessment, a negligible change in circumference from the onset of therapy to the final examination in group A of an average of -0.06 ± 0.50cm (0.16 ±1.25%) from 42.48±9.47cm to 42.42±9.53cm and in group B of 0.21±0.60cm (0.10±1.52%) from 39.62±7.55cm to 39.50±7.48cm. Also in group C the circumference reduction of 0.82±0.93cm (0.90±2.01%) from 42.51±9.24cm to 41.11±6.98cm was very small.

In contrast, the percental decrease of periarticular swelling at the patella center was significant for all groups (Fig. 1b): In group A the average circumference at the beginning was 40.72±4.37cm and decreased to 40.35±4.49cm, i.e. by 1.10±1.41% (0.59±0.47cm), while in group B the circumference decreased from 41.74±3.30cm to 41.45±3.30cm, that is by 1.46±0.97% (0.62±0.43cm). For group C the knee swelling was reduced from 40.21±3.56cm to 39.77±3.54cm, i.e. by 3.37±1.44% or 1.49±0.75cm.

**Assessment of knee joint mobility:** Prior to the initiation of the treatment, the average extension deficiency in group A was 6.37°±5.93°, group B lacked an average of 6.55°±5.93° of extension and those in group C (of) an average of 7.20°±6.35° to bring the knee into the neutral position. The average measured extension loss in group A after 6 units was 6.13°±5.61°. In group B this deficiency was 6.15°±5.85°, while in group C a value of 4.98°±5.34° could be determined. At the end of the treatment, the mean extension deficiency was 5.81°±5.50° in group A, 6.12°±5.79° in group B and 4.39±5.31 in group C.

In group A patients the extension deficiency decreased by an average of 0.89°±2.72° and in group B by 0.38°±1.54°. In group C the extension of the knee joint improved by an average of 2.81°±3.30°, which was significantly more compared to groups B and C. In sum, patients in group C achieved a significant improvement of the extension of the knee joint compared to groups A and B during the 12 TU (Figure 2a).

At the initial assessment, patients in group A had an average flexion deficiency of 33.69°±14.64°. Patients in group B had a lack of 34.70°±16.25°, and in group C 38.18°±13.88° for complete flexion of the knee joint. At the second visit, the patients in group A had an average deficiency of 30.62°±11.53°, in group B 31.78°±14.27° and in group C 31.55°±11.62°. At the end of the treatment, the flexion deficiency in group A was 29.90°±12.38°. Group B had an average deficiency in flexion of 31.61°±12.38°, group C one of 31.73°±22.0°. After 12 units, the flexion deficiency in group C had decreased significantly more by 10.02°±11.73° than in groups A and B, with an improvement of only 3.79°±6.37° and 3.24°±3.79°, respectively. In sum patients in group C achieved a significant improvement of the flexion of the knee joint compared to group A and B (Figure 2b).

In group A, the range of motion had only improved by an average of 5.29°±6.65° after completion of the 12 therapy units. Also in group A the improvement of knee motion was comparatively low with only 3.97°±4.17° (Fig. 2c). In group C, however, the total range of motion of the knee joint improved significantly by 14.37°±11.94°.

**Subjective evaluation of the therapy outcome:** Of the 120 questionnaires sent out, 75 completed questionnaires could be analyzed. Of these, 21 were assigned to group A and 27 each to groups B and C (Tabl. 1). In group A, which was only treated with physiotherapy, more than half of all patients (62%) felt no change or even a worsening of the pain symptoms after completion of the therapy, while in group B, patients with additive taping, reported an improvement of the pain symptoms (52%). Here, only 4 patients (16%) stated that their knee tended to worsen. The majority of patients in group C with physiotherapy and Sanotaping® rated the regression of knee pain after completion of treatment as very good (52%) or good (48%). This also reflects the classification of the pain on the pain scale: All patients surveyed rated the remaining pain at "2", i.e. as a low pain experience. Also in group B, the majority (61%) rated the pain between 1 and 3 on the pain scale; however, 12% reported pain in the upper third of the pain scale (6 - 9) despite taping. In group

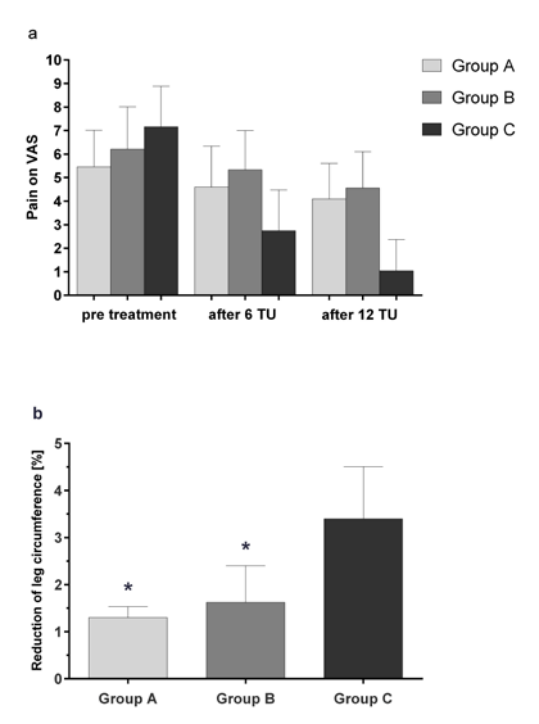


**Figure 2** Comparative illustration of the therapy results of the three patient groups after 12 therapy units with different physiotherapeutic regimens: group A - physiotherapy only, group B - physiotherapy+taping, group C - phy-siotherapy+sanotaping® a Reduction of the knee joint's extension deficiency. b Improvement of the flexion deficiency. c Increase of the overall range of motion. Data expressed as means±STD; *p<0.01 vs. group C.

A, about 70% of all patients reported pain on the pain scale in the lower third and 23% in the middle third.

Regarding the range of motion of the affected knee joint, it is noticeable that in group A more than 60% of the responding patients stated that they did not feel any change in the range of motion or that they were still comparatively poorly mobile. In group B, 35% describe a very good to good mobility. In contrast, all patients who received Sanotaping® report an improvement in knee mobility. In both groups A and B, 76% of the knee mobility was described as either unchanged or slightly decreased. The average in both groups was no change, while in group C all patients (100%) reported a significant increase in mobility.

96% of the patients who received Sanotaping® combined with physiotherapy (Group C) reported an improvement in QoL (Table 1). Also in groups A and B about 50% of the study participants experienced an improvement QoL. In about 10% of the study participants in groups A and B, however, the quality of life had decreased after the treatment had been finished. The majority of the patients who only received physiotherapy as well as those who were additionally treated with tape were satisfied with the course of treatment (Table 1) and considered the therapy to be (very) effective. In group A, however, another 38% had an indifferent opinion, in group B the rate was 12%. Interestingly, in group C 97% of the patients rated the therapy as effective, none of them felt it was ineffective.

## Discussion

Injuries, degenerative disorders and thus pain in the knee joint are among the most frequent causes of disability and reduction of QoL today [9, 10]. Since young people are often affected by these diseases, it is a socioeconomically relevant topic [9,11]. While the major developmental steps in (imaging) diagnostics [12, 13] and operative therapy have already been included in guidelines [14] and everyday clinical practice, there is still a lack of implementation of the findings of modern rehabilitation and physiotherapy [15]: physiotherapy, which is limited in duration (usually 12 units) and also in time (<25 min.), is prescribed in an almost standardized manner and primarily focuses on the current (knee) symptoms. There is neither time for a primary, orienting examination of the axial skeleton, nor can body regions be addressed that would support the recovery of the current symptomatology. It is evident that this type of physiotherapeutic treatment often does not achieve the desired result.

In contrast, the physiotherapeutic complex therapy applied in the present study shows how optimal restoration of mobility, muscle strength and thus walking ability can be achieved in a relatively short time (12 units of 60 min each). A short examination (approx. 15 min) of the musculoskeletal system at the start, combined with a simultaneous patient interview (anamnesis), allows the identification of an individual therapy approach: Different combinations of physical therapy with electricity [16, 17] and cryotherapy [18, 19], manual therapy with stretching of the ischio-crural muscles, walking exercises and isometric, excentric, concentric or isokinetic coordination training with stand-up exercises, is not only effective for the patient, but also does not require excessive personnel resources for the practical implementation.

Prerequisite for the participation of the patients in the study was not only their suitability for and consent to participate in it, but also their willingness to actively participate in the therapy. From the very beginning, an awareness of their clinical symptoms and the awareness that this is the only way that physiotherapeutic treatment can bring the desired benefits was generated [20, 21]. The patients were also advised to do some exercises for their disease pattern on the days between the therapy units to support the healing process. This could not be monitored; however, the results of the study suggest that the majority of patients followed this advice. Accordingly, it can be postulated that this individual therapy plan leads to a good adherence of the patients, which has a very positive impact on the outcome of the treatment and thus on the QoL (motivation and willingness to recover).

In the physiotherapeutic complex therapy different physical applications were used. The entire therapy focused primarily on the decrease in swelling and pain symptoms. The recovery of full extension (0°-position) in the knee joint was the primary goal here, as this has the greatest influence on the restoration of the physiology of the knee joint. The optimal time to start stretching exercises depends on the degree of injury [17]. The mobilization of the injured tissue helps to reduce undesired scarring, i.e. the scar that impedes motion, and promotes tissue re-capillarization ([22]. Thus stretching exercises prevent muscle contractures [23], prevent muscle shortening [24] and increase the “Range of Motion” (ROM) [22,25].

Transcutaneous electrical nerve stimulation (TENS) addresses afferent nerve pathways of the painful tissue by means of monometric or asymmetric compensated (biphasic) rectangular pulses [26], resulting in pain reduction in the majority of patients, ≥70% for acute and ≥60% for chronic pain. The principle of TENS is based on the gate control theory first defined by Melzack and Wall in 1965 [16], which states that there is an inhibition of the pain fibers in the spinal cord when the Aß fibers are stimulated with a current frequency of 80-100 Hz [27]. Alternatively, the Aδ fibers, which are stimulated on low-frequency pulses (2 - 5 Hz) and lead to pain reduction by releasing encephalin, a neuropeptide with opioid action in the spinal cord [17], can be stimulated.

Cryotherapy has an edema-reducing effect through vasoconstriction and contributes to a slow-down of biochemical processes by inducing reduced blood flow, which in sum has an anti-inflammatory effect. In addition, a decrease in muscle tone caused by cryotherapy promotes pain relief [18, 19]. The combination with taping should provide support. It has three different functions: When applied correctly, it leads to a compression of the damaged tissue and thus to a reduction in swelling. It fulfils a supporting function (augmentation) of the capsule-ligament apparatus of the joint, whereby the degree of movement restriction depends on the material applied [28, 29]. Third, it leads to an improved perception (proprioception) of the motions performed. Interestingly in the present study,

**Table 1** Evaluation of the follow-up questionnaires six months after finishing the different treatment regimes after knee injury or degenerative disease. Group A with physiotherapy only (21 forms), group B with physiotherapy and taping (26 forms) and group C with physiotherapy and sanotaping®.

| | VERY GOOD | GOOD | UNCHANGED | LESS | NONE | NO ANSWER |
|---|---|---|---|---|---|---|
| **PAIN REDUCTION AT END OF TREATMENT** | | | | | | |
| Group A | 19.0 % | 19.0% | 33.3 % | 28.6 % | 0 | 0 |
| Group B | 16.0 % | 36.0 % | 32.0 % | 16.0 % | 0 | 8.0 % |
| Group C | 51.9 % | 48.1 % | 0 | 0 | 0 | 0 |
| **PAIN REDUCTION TODAY** | | | | | | |
| Group A | 28.6 % | 14.3 % | 42.9 % | 14.3 % | 0 | 0 |
| Group B | 15.4 % | 19.2 % | 42.3 % | 15.4 % | 7.9 % | 3.8 % |
| Group C | 51.9 % | 48.1 % | 0 | 0 | 0 | 0 |
| **KNEE RANGE OF MOTION TODAY** | | | | | | |
| Group A | 28.6 % | 9.5 % | 38.1 % | 23.8 % | 0 | 0 |
| Group B | 11.5 % | 23.1 % | 38.5 % | 23.1 % | 3.8 % | 3.8 % |
| Group C | 0 | 100% | 0 | 0 | 0 | 0 |
| **EFFICACY OF THERAPY** | | | | | | |
| Group A | 23.8 % | 19.0 % | 38.1% | 19.0 % | 0 | 0 |
| Group B | 19.2 % | 42.3 % | 11.5 % | 19.2 % | 7.7 % | 3.8 % |
| Group C | 55.5 % | 40.7 % | 3.8 % | 0 | 0 | 0 |
| **SATISFACTION WITH APPLIED THERAPY** | | | | | | |
| Group A | 14.3 % | 33.3 % | 33.3 % | 14.3 % | 4.8 % | 0 |
| Group B | 19.2 % | 53.8 % | 11.5 % | 7.7 % | 7.7 % | 3.8 % |
| Group C | 51.9 % | 44.4 % | 3.8 % | 0 | 0 | 0 |
| **IMPROVEMENT OF QUALITY OF LIFE (QoL)** | | | | | | |
| Group A | 19.0 % | 38.1 % | 33.3 % | 9.5 % | 0 | 0 |
| Group B | 15.4 % | 34.6 % | 38.5 % | 7.7 % | 3.8 % | 3.8 % |
| Group C | 59.3 % | 37.0 % | 3.8 % | 0 | 0 | 0 |

patients in group B did not seem to profit from additive taping. One explanation may be the rigidity of the tape used, which was attached to the knee and perhaps rather hindered the physiological movement sequence. It can be postulated that a smoother tape would have led to different results.

Sanotape® is a CE-certified medical product consisting of two components, a very thin metallized, reflecting polymer and tape as a carrier. According to the manufacturer, when applied in an occlusive manner over the painful region, the reflecting effect of the metal coating should lead to a condenser effect in the case of pain-induced increased perspiration of the skin, which in turn leads to increased evaporation of the acidity in the inflamed tissue. In this acidic environment, the metallized polymer reacts - sometimes even visibly - and reduces the acid protons to molecular hydrogen (Figure 3), which binds free radicals under occlusive conditions. At the same time, it is postulated that galvanotaxic processes increase the potential energy of tissue fluid, and that the influx of macrophages and neutrophilic granulocytes from the blood into the damaged tissue is promoted. This could explain the analgesic effect of Sanotaping® described by patients. In addition, the compression of the tape reduces the swelling of the injured tissue and promotes a decrease in edema, as well as a sustaining effect. The increased capillary flow in the blood and lymph vessels leads to a more effective delivery of micronutrients and in parallel to a faster elimination of damaging toxins and necrotic tissue. This also appears to promote the healing of scars: Under the Sanotaping® the visible post-operative scars were smooth and relatively thin. Maybe this also is dependent on the underlying tissue scars.

## Conclusion

This prospective, randomized study to analyze the efficacy of physiotherapeutic interventions in post-traumatic or degenerative injuries of the knee joint shows that the early application of such (complex) therapy is of high relevance. Not only does it have a local impact on the lower extremity, but also the entire physiology of the body is positively impacted and the quality of life is improved. An additionally applied tape has no significant benefit. However, the metallized, gold-silver polymeric film of Sanotaping® reflects the imbalance of the tissue tone caused by injury or degeneration and thus leads to a decrease in tension with an increase in mobility and pain reduction. Its assessed sustainability should be a base for the implementation

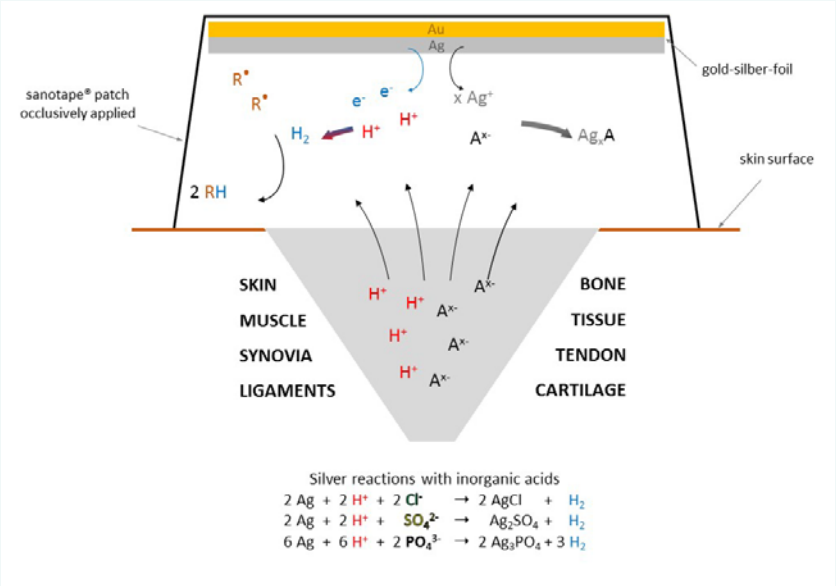


**Figure 3** Scheme of the theory of the mode of action of sanotape®. The injured and/or degenerative altered tissue generates an acidic environment on the skin surface which interacts with the metallic surface of sanotape® so that excess anions are "buffered". This results in a generation of the milieu towards the physiological one and counteracts hyperacidity, which - among other factors - leads to pain reduction. (H+ = (acid) proton, Ax- = inorganic acid anion, Ag+ = silver ion, AgxA = insoluble silver salt, e- = electron, H2 = molecular hydrogen, R• = radical, RH = neutralized radical).

of the combined therapy with functionally applied, metallized polymers (Sanotaping®) in non-surgical as well as in pre- and postoperative physiotherapy and rehabilitation.

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