

Manual Khalifa Therapy in Patients with Completely Ruptured Anterior Cruciate Ligament in the Knee: First Results from Near-Infrared Spectroscopy

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Abstract

Background: Manual Khalifa therapy has been practiced in Hallein, Austria, for more than 30 years; however, there are no scientific results available on the topic. **Aims:** The goal of the present study was to investigate possible acute effects of Khalifa therapy on regional oxygen saturation of knee tissues in patients with completely ruptured anterior cruciate ligament. **Materials and Methods:** We investigated 10 male patients (mean age \pm standard deviation (SD) 35.9 ± 6.1 year) using a four-channel oximeter. The sensors were applied anterolaterally and anteromedially, beside the patella, on both the injured and the healthy (control) knee. **Results:** The results of the controlled study showed that values of oxygen saturation on the knee with the ruptured ligament were significantly increased ($P < 0.001$) immediately after Khalifa therapy, whereas the values on the control knee showed insignificant increases. Baselines values of the anterolateral side of the injured knee were significantly ($P < 0.001$) different from those of the anterolateral side of the control knee. The same effect was present on the anteromedial side; however, with a lower degree of significance ($P < 0.05$). **Conclusions:** Khalifa therapy was clinically successful in all 10 patients. Further, investigations and analyzes are necessary to explain the underlying mechanism.

Keywords: Anterior cruciate ligament, Khalifa therapy, Metabolism, Near-infrared spectroscopy, Regional oxygen saturation

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Introduction

There are different measurement methods for the investigation of changes of tissue oxygenation. Near-infrared spectroscopy (NIRS) was described for the first time by Jöbsis in Science in 1977.^[1] It is a non-invasive technology, and the portable multichannel monitoring equipment led to numerous clinical applications. Our research group was one of the first to perform a several basic and clinical studies on brain metabolism on this topic.^[2,3]

Besides brain function monitoring, NIRS is also used in the clinical practice for investigations of the lower extremities; however, there are only few reliable basic and clinical data available.^[4]

Manual therapy is an important medical method using different techniques. Mohamed Khalifa is a therapist from Hallein in Austria who has been practicing manual therapy in orthopedic indications for more than 30 years.^[5,6] His treatment, the so called "Khalifa therapy," which has been developed by himself, is mainly based on pressure and the application of certain rhythms, and with it he seems to be able to speed the self-healing processes of the human body. He has treated many top-athletes from all over the world; however, his method has never been investigated in detail within interdisciplinary scientific studies. This is now possible thanks to innovative techniques in medicine (e.g., different biomarkers), which have broadened the methodological spectrum; for example, the NIRS method can now-a-days be used

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easily by the bedside, which wasn't the case in its 1st days.

The Khalifa technique is described in some books;^[5,6] however, as already mentioned, there is no description in the scientific literature at the moment. The goal of the present study was to investigate for the first time possible acute effects of Khalifa's therapy on the regional oxygen saturation of the knee tissues in patients with a completely ruptured anterior cruciate ligament (ACL).

Materials and Methods

Patients

A total of 10 male patients with a mean age \pm (SD) of 35.9 ± 6.1 years (range: 19-45 years), a height of 177.6 ± 7.2 cm, and a weight of 77.0 ± 7.7 kg were investigated. Inclusion criteria were:

- Unilateral complete rupture of the ACL, verified by magnetic resonance imaging, no preceding surgical intervention
- Male
- Age: 18-49 years
- Normal body weight: Body mass index 18-26
- Regular exercise level
- Knee instability: Experienced at least one giving-way
- Dysfunction: knee range-of-motion: Reduced or inhibited
- Able to a) walk 10 m without crutches, and b) stand on one leg.

Exclusion criteria

- Metabolic disorders like diabetes mellitus
- Autoimmune diseases.

Two of the patients had a rupture of the left ACL, the other 8 of the right ACL. Three had received the injury when playing soccer, six when skiing, and one when getting out of his car.

They were informed about the nature of the investigation as far as the study design allowed and were not paid for their participation. The study was approved by the Ethics Committee of the University of Salzburg, Austria (21-232 11-12 sbg), and registered at clinicaltrials.gov under the ID-no. NCT01762371. All participants provided written informed consent.

Manual therapy

Khalifa therapy is described as functional-pathological.^[5] In this approach, function is the primary concern, not anatomy. The most important thing is not the ruptured ligament itself, but its function/dysfunction. Khalifa therapy restores the function of the knee in a natural way. During the 60-90 min of his manual therapy, he

applies pressure to the injured knee in order to activate the self-healing processes of the human body, using his hands as an instrument for both measurement and therapy. Over periods of varying length, he applies increasing pressure on a spot before moving on to the next spot. The frequency of pressure application depends on the patient's physiological reaction. The force of the pressure is not comparable to that normally used in acupressure in traditional Chinese medicine,^[4] it is much higher and at the moment impossible to measure because also frequency plays a significant role. We are developing an instrument to measure the combination of these two parameters (intensity of force and frequency) continuously and simultaneously to obtain numerical data.

Mohamed Khalifa's method is based on manual pressure of varying frequency and does not damage the body, but supports it in its own natural healing activities. If one cuts through an elastic band and sews it together again, one cannot expect it to be as elastic at the stitching point as it was before. It is the same with human ligaments, and if the elasticity is disrupted anywhere in the human body, the whole system is affected.^[5,6]

Evaluation parameters

The measurements of regional oxygen saturation (rSO_2) in Khalifa's institute [Figure 1] were performed using a four-channel INVOS 5100C Oximeter [Somanetics, Troy, USA; Figure 2]. The principle of this system is based on NIRS technology, a non-invasive method for measuring regional oxygenation through the intact skin.^[2] Near-infrared light (730 nm and 805 nm) is emitted through the skin, and after passing different kinds of tissue (muscle and bone), the returned light is detected at two distances from the light source (3 cm and 4 cm). Based upon this principle, the spectral absorption of blood in deeper structures (2-4 cm) can be determined and defined as rSO_2 .^[2,4] The different tissues of the human body have different absorption characteristics, and therefore it is not easy to define in which kind of tissue the rSO_2 value is measured.

Procedure

Approximately, 3 h before starting the measurement, both legs were shaved. The skin was then cleaned with the enclosed skin-prep pad and dried with a gauze pad. After removing the protective backing label from the adhesive side of the sensor, four sensors were applied below the right and left lateral side of the patella of both legs [Figure 3]. Calibration is performed automatically. To minimize an external light influence, the knees were covered with a surgical cloth during the recording procedure. The rSO_2 data were recorded before the start and after the end of the manual therapy (three readings each within approximately 2 min).



Figure 1: Manual Khalifa therapy. Mohamed Khalifa practicing his manual therapy in Hallein, Austria with permission of M. Khalifa, Jan 8th, 2013

All patients were investigated in a supine position under the same conditions. The study was performed as a controlled study. The parameter rSO_2 was simultaneously measured at four sites: Laterally and medially at both knees the injured one and the healthy one (control; this knee did not receive any therapy or manual manipulation, only the measurement sensors were applied). To avoid a potential technical recording bias, the four channels of the equipment were used in a randomized order.

Statistical analysis

The rSO_2 values of both legs were tested with one-way repeated measures ANOVA (SigmaPlot 12.0, Systat Software Inc., Chicago, USA). The Holm-Sidak method was used for *post-hoc* analysis. The level of significance was defined as $P < 0.05$.

Results

A total of 10 patients completed the study, and the measurements could be performed without any technical problems. Figure 4 shows the increase of the rSO_2 values after manual Khalifa therapy on the injured knee. Typical values after treatment are also shown exemplary in Figure 2 ($rSO_2 = 95\%$ anterolateral and anteromedial on the injured knee, and $rSO_2 = 88\%$ and 77% , respectively, anteromedial and anterolateral on the control knee).

This increase was highly significant ($P < 0.001$), on the anterolateral and the anteromedial side of the injured knee. In addition, it should be noted that the baseline values of the anterolateral [A in Figure 4] and the anteromedial [C in Figure 4] side of the injured knee presented a significant difference ($P < 0.01$). This is probably caused by the fact that on the anteromedial side of the knee the arteries are closer to the surface than on the anterolateral side. It was interesting that already the baseline values of the anterolateral side of the injured knee [A in Figure 4] and those of the anterolateral side of the healthy (control) knee [B in Figure 5] showed significant differences ($P < 0.001$). The same effect could be seen on the anteromedial side (C vs. D); however, with a lower significance ($P < 0.05$).

The values of rSO_2 on the healthy knee are presented in Figure 5. No statistically significant differences were found on this side maybe because of the small number of patients.

The function of all 10 injured knees was restored after manual therapy, and the patients were able to walk, run, jump [Figure 6], and bend their knees immediately after the end of the treatment. None of this had been possible before without severe restrictions. The functional parameters will be described in studies by other research groups.



Figure 2: Near-infrared spectroscopy monitor. Equipment for measuring regional oxygen saturation used in this study

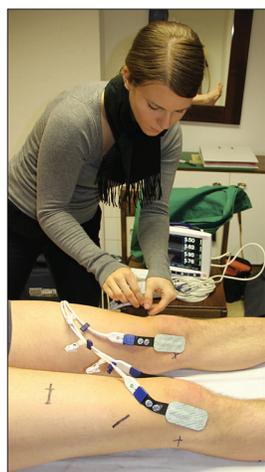


Figure 3: Measurement sites. Measurement sites with applied sensors before/after manual Khalifa therapy with permission of the depicted person (co-author of this study)

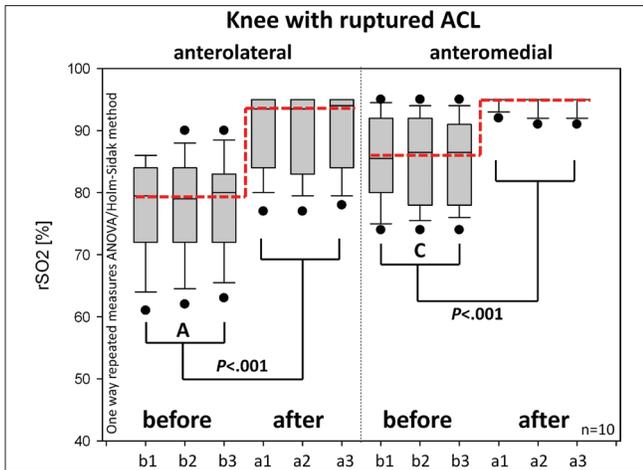


Figure 4: Changes in regional oxygen saturation on the injured knee. Box plot (ends of boxes: 25th and 75th percentile; line at the median; error bars: 10th and 90th percentile) presentation of rSO₂ values before and after manual therapy. b1, b2, b3: Readings before manual therapy; a1, a2, a3: Readings after manual therapy

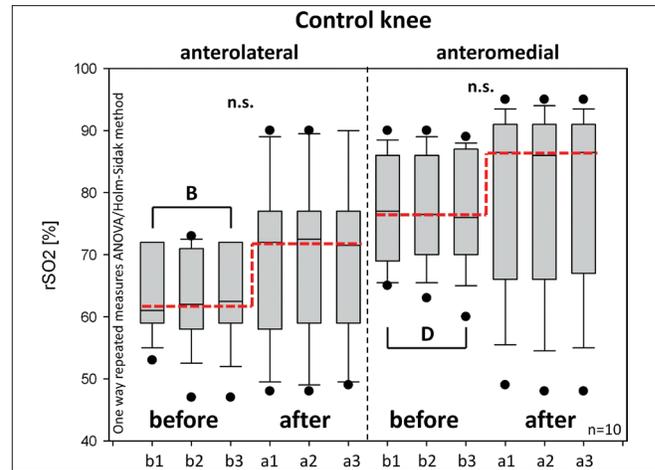


Figure 5: Changes in regional oxygen saturation on the healthy control knee. Box plot presentation of changes of rSO₂ values in 10 patients before and after manual therapy on the control knee. For further explanations, Figure 4



Figure 6: Demonstration of restored knee function. Immediately after manual Khalifa therapy, the patient was able to jump and bend the injured knee completely, which had been impossible before treatment. With permission of the patient

Discussion

The application of complementary and alternative medicine as a means to accelerate the process of regeneration is still a controversially discussed approach. Although manual therapies like Khalifa therapy offer a natural and cost-effective intervention for rapid regeneration, they have been given a little attention in the scientific community.

In a previous study,^[4] we have shown that acupressure at the Xiyangguan acupoint (GB33) affects regional oxygen saturation of the deeper knee tissues measured by NIRS. In 12 healthy volunteers, acupressure stimulation was performed for only 5 min. The results of this controlled study showed a significant increase of rSO₂ on the

stimulated side of the knee, whereas the opposite side on the same knee showed insignificant changes. These results also serve as first basis for the present study, although they are not directly comparable. The results of the present study reach a different dimension that is the increases were significantly higher.

The transmission and absorption of near-infrared light in the human body tissues contains information about hemoglobin concentration changes. Using NIRS, it is possible to quantify blood flow, blood volume, oxygen consumption, reoxygenation rates, and muscle recovery time.^[7] NIRS can penetrate the tissue in a depth of 2-4 cm, whereas for example laser doppler flowmetry (LDF) can only penetrate the tissue in a depth of about 1-3 mm. Moreover, NIRS is more sensitive than LDF with regard to detecting changes in tissue inflow,^[4,8] and it has also been suggested as a method for arthroscopic evaluation of low grade degenerated cartilage lesions.^[9]

This is the first study, which evaluates the acute effects of manual therapy on the regional blood oxygenation of the knee tissues using the NIRS. As already mentioned before, the blood flow velocity was found to be increased after continuous digital acupressure.

There are also some aspects, which have to be mentioned as possible limitations of study: For example, environmental temperature could possibly influence the results, but this is not very probable because the measurements in all 10 patients were performed under similar conditions. Moreover, the manufacturer of the measurement system states in the manual that “temperature has no influence” on the measurement procedure. We will discuss this topic in another publication, which will

deal with thermal imaging. The articular cavity can also influence the results, and similar to the aforementioned paper,^[4] this could also be a reason for the variation of absolute values among the patients before the procedure.

Each movement of the human body causes tensions in different kinds of tissue (joints, muscles, nerves, and cells). These tensions are also responsible for the adaptation of the body, and they have been used to accelerate the regeneration mechanisms by some therapeutic methods (e.g., acupressure) for hundreds of years, which is supported by current research.^[4,10-12] The exact mechanism of this mechanotransduction cannot yet be explained in detail at the moment.^[13-15] It is also unclear whether and to which extent a dynamic application of pressure (certain amplitude and/or frequency) influences these regeneration processes,^[16-18] and thus further investigations and analyses are necessary to explain the underlying mechanism. This is also considered necessary because at the moment Khalifa has no students to whom he teaches his method, which is not easy to learn. The method should be scientifically investigated before being taught to others.

Conclusions

Manual Khalifa therapy was clinically successful in all 10 patients with completely ruptured ACL in the knee. The values of regional oxygen saturation (rSO₂) on the knee with the ruptured ACL were significantly increased immediately after Khalifa therapy, whereas the values on the other knee (control side) showed insignificant increases. Baselines values of the anterolateral side of the injured knee were significantly different from those of the anterolateral side of the control knee. The same effect was present on the anteromedial side; however, with a lower degree of significance.

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