RESEARCH ARTICLE

Ultrasound-Guided Intraarticular Electrical Stimulation, a New Intervention for Improving Physical Activity and Quality of Life in Patients with Severe Knee Osteoarthritis: Cases Report

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ABSTRACT
Knee osteoarthritis is one of the diseases that cause degeneration of articular cartilage, subchondral bone, and chronic joint pain and stiffness. While there is no effective treatment for inhibiting the progression of its advancement, there are various interventions for managing symptoms of this condition in its early stages and a few treatments for advanced stages. In patients with severe knee osteoarthritis, the most recommended treatment is surgery. However, this procedure is contraindicated for many patients because of their comorbidities. In this study, a new physical intervention for managing the symptoms of advanced knee osteoarthritis in patients whose surgery is not indicated has been investigated, and its results have been reported. These data demonstrate that this method seems to be effective in pain and stiffness reduction and improves physical activity and quality of life. More studies are needed to ensure the result of this study in the future.

KEYWORDS
Knee osteoarthritis, knee pain, physical therapy, rehabilitation, physical activity, COVID-19, noninvasive treatment, osteoarthritis

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1. Introduction
Osteoarthritis (OA) is the first cause of disability and is the number two reason that causes a reduction in physical activity (Badley, 1995). The most affected joint by osteoarthritis is the knee joint (Thomas et al., 2003), which can lead to gait impairments and disability (Davis et al., 1991), musculoskeletal complications like losing strength (Liikavainio et al., 2008), limitation in range of motion and physical activity, and increased risk and fear of falling (Cumming et al., 2000). In the end stages of knee OA, patients experience a great deal of pain during physical activity (Atamaz et al., 2006), and most of them respond poorly to recommended noninvasive treatments such as manual therapy techniques (Pollard et al., 2008), non-steroidal anti-inflammatory drugs (NSAID) (Cooper et al., 2019), intraarticular injections (Ayhan et al., 2014), Transcutaneous Electrical Nerve Stimulation (TENS), orthoses, therapeutic exercises, the use of assisted devices, education, weight loss, acupuncture, laser therapy, and therapeutic ultrasound (Jamtvedt et al., 2008). Normally, for these patients, surgical procedures are recommended. However, some patients are not candidates for surgery because of other underlying diseases like severe cardiovascular complications, insufficient bone stock for reconstruction, active knee sepsis, active infection, extensor mechanism dysfunction, and medically unstable cases (Hsu & Siwiec, 2021) or when patients refuse surgery for any reason. So what is the solution for patients with severe knee OA whose surgery is not indicated for them? Advancing pain and dysfunction in this group of patients leads to disability and poor quality of life. In this report, a new method for managing symptoms of advanced knee OA and its impact on the quality of life of these patients will be discussed.

2. Literature Review
Knee osteoarthritis is one of the main reasons for the reduction in functional performance and physical activity secondary to pain (Thomas et al., 2003). Based on Davies et al. (1991) study, patients with radiographic signs of knee osteoarthritis experience difficulties and pain while performing physical activities. Reduction in strength of muscles that are in charge of function in knee

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joints like quadriceps femoris muscle (Liikavainio et al., 2008) is another one of the factors that cause impaired physical function. There are several interventions for treating symptoms of the knee osteoarthritis like exercise (reduction in pain and improvement in physical activity, moderate-quality evidence), braces and orthoses (unclear, low-quality evidence), electromagnetic field (no difference between electromagnetic fields and placebo in improving pain and function, moderate-quality evidence), acupuncture (reduces pain, moderate-quality evidence), transcutaneous electrical nerve stimulation (pain reduction, moderate-quality evidence), low-level laser therapy (reduction in pain and improvement in function, moderate-quality evidence), therapeutic ultrasound (unclear, low-quality evidence), and electrical muscle stimulation (unclear, low-quality evidence) (Jamtvedt et al., 2008).

Intraarticular corticosteroid injections are other treatments for short-term management of moderate to severe pain in people with osteoarthritis. Also, hyaluronic acid injections might be beneficial for pain reduction in mild OA of the knee for up to 2 years (Ayhan et al., 2014). NSAIDs can be beneficial in some cases; however, they have several adverse effects that influence the gastrointestinal, cardiovascular, and renal systems (Pollard et al., 2008).

In cases of failure of all conservative management, the suggested treatment is surgical procedures. But it must be noted that in patients with the existence of comorbidities or active infection, ineffective quadriceps muscle, neuropathic arthropathy, poor soft-tissue coverage, psychiatric disease or alcohol and drug abuse, inadequate bone stock, inappropriate for major surgery and anesthesia, poor motivation, and idealistic expectations surgical treatment is contraindicated (Hsu & Siwiec, 2021).

In patients with severe knee OA, advancements in the levels of pain and stiffness lead to immobility which causes muscle wasting, overeating, and decreased quality of life (Alhassan et al., 2022). This situation causes an impaired cycle since exercising is limited due to pain, stiffness, and fear of falling (Cumming et al., 2000) and at the same time exercising is one of the best interventions for reducing pain and stiffness and improving the quality of life (Jamtvedt et al., 2008).

3. Methodology

3.1 Patient’s characteristics:
The chosen sample consists of 17 patients (20 knee joints in total) with symptoms of knee OA confirmed by x-ray. All of them were aged 60 years or older (table 1), and based on Kellgren and Lawrence’s classification (Kohn et al., 2016), they all had stage 4 knee OA. All of them were referred to orthopedic surgeons but based on their underlying diseases, surgery was not indicated, and they were referred back to rehabilitation centers for non-invasive treatments. All of these cases tried physical therapy interventions, including laser therapy, extracorporeal shockwave therapy, manual techniques, TENS, and other treatments like intraarticular hyaluronic acid injection, intraarticular steroid injection, and PRP injection in the less than two years before starting this treatment. None of the above-mentioned procedures were effective for managing their pain and improving their quality of life. None of the cases had any therapeutic procedure at least 5 months before starting this course of treatment. None of them were able to perform any therapeutic exercise as they reported that any exercise would increase their pain; hence they were afraid of doing it. Four of these patients were wheelchair-bound, eight of them walked with the assistance of a walker, and the rest of them walk with a noticeable limp. All of them were experiencing fear of falling, which caused higher levels of immobility. Nine of them reported that the onset of a sudden increase in their symptoms was after they were infected with COVID-19. Patients were completely aware of the characteristics of the study and provided written informed consent. All of the treatment sessions were accrued in the Naji cooperative rehabilitation center, and all of the patients were examined and supervised by a physical therapist and a physical medicine specialist. Patients with diabetic polyneuropathy, severe lumbar canal stenosis, and obesity were excluded from the study.
### Table 1: Patient’s characteristics.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex/ Age</th>
<th>BMI (kg/m²)</th>
<th>Duration of symptoms (M)</th>
<th>Walking assistance</th>
<th>Post COVID-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F/ 69</td>
<td>24.8</td>
<td>72</td>
<td>walker</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>F/ 73</td>
<td>26.1</td>
<td>120</td>
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<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>M/ 65</td>
<td>23.4</td>
<td>66</td>
<td>walker</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
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<td>25.1</td>
<td>78</td>
<td>walker</td>
<td>No</td>
</tr>
<tr>
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<td>24.7</td>
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<td>wheelchair</td>
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</tr>
<tr>
<td>6</td>
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<td>27.1</td>
<td>90</td>
<td>wheelchair</td>
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</tr>
<tr>
<td>7</td>
<td>F/ 66</td>
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<td>_</td>
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<td>8</td>
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<tr>
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<td>72</td>
<td>walker</td>
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<tr>
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<td>24.4</td>
<td>96</td>
<td>_</td>
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<tr>
<td>11</td>
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<td>25.4</td>
<td>84</td>
<td>_</td>
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<tr>
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<td>23.6</td>
<td>76</td>
<td>_</td>
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<tr>
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<td>wheelchair</td>
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</tr>
<tr>
<td>15</td>
<td>F/ 71</td>
<td>26.8</td>
<td>84</td>
<td>walker</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>F/ 71</td>
<td>26.2</td>
<td>88</td>
<td>_</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>F/ 70</td>
<td>25.3</td>
<td>96</td>
<td>walker</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>69.17 (4.05)</strong></td>
<td><strong>25.04 (1.15)</strong></td>
<td><strong>95.76 (27.53)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2 Intervention:
All of the patients underwent 10 sessions of intraarticular electrical stimulation during six weeks: the first week, 3 sessions every other day, the second and third weeks, two sessions per week, and the rest of the sessions were once a week. After 10 sessions, all of them had a maintenance treatment plan which was one session once a month for follow-up and getting the treatment if it was necessary. The electrical stimulation was provided by a nerve and muscle stimulator device, and it was applied through 1 inch needles which were entered with ultrasound guidance since, in this way, it is more accurate than blind insertion (Fang et al., 2021). The area of entry was cleansed. Patients were supine with 90 degrees of knee flexion, and an ultrasound knee examination was performed with a 6–15 MHz linear array transducer. Needles were inserted into joint space with an anterolateral, anteromedial, and mid-patellar approaches (figure 18) under ultrasound guidance. Because the needles were extremely thin (0.25mm), none of the patients reported any pain during the insertion and electrical stimulation. All of the patients were treated by one physical therapist. Each session included 15 minutes of treatment (frequency: 100 Hz), and for the rest of the time, each of them was evaluated and advised to be more physically active as much as they could without worsening their symptoms. After the fifth session, therapeutic exercises for strengthening the muscles that are in charge of movement in lower extremities joints were added to the treatment plan. Patients were told that if any of them experienced an increase in their level of Pain, they stopped the exercise immediately and reported to the physical therapist.

4. Results and Discussion
4.1 Results and reports
17 patients (10 females and 7 males, mean age 69.17 ± 4.05) with Pain and stiffness in the knee joint line secondary to grade 4 knee osteoarthritis were enrolled and underwent an ultrasound guided intraarticular electrical stimulation. According to VAS and WOMAC scores, after 10 sessions, all of the patients reported a significant (p<0.0001) decrease in the level of Pain in both rest and activity (Table 2). In addition to that, all of the subjects show a significant (p<0.0001) improvement in physical activity (Table 2).
and fear of falling as well as fear of performing therapeutic exercises and a reduction in stiffness level. After the 5th session, when the therapeutic exercise was added to the program, patient satisfaction from being able to perform the therapeutic exercises was expressive. Two of the wheelchair-bound patients became able to walk with the assistance of a walker, and one of the patients who walked with the assistance of a walker became able to walk without any assistance.

In the one-year follow-up, 12 of the patients were required to have one session per month of intraarticular electrical stimulation, and they reported that this maintenance treatment keeps their symptoms and activities at an acceptable level. Another of the wheelchair-bound patients could walk with the assistance of a walker.

One of the patients got infected with COVID-19 during the one-year follow-up, which caused a sudden increase in their symptoms; however, based on patients’ reports, the maximum level of Pain that they were experiencing was much less than the time before getting treated. For this particular patient, after healing from the COVID-19, six sessions of intraarticular electrical stimulation (3 sessions per week) were performed. The patient continued to do their exercises for a shorter duration during COVID, but after 6 sessions, they returned to the regular program that they had before getting infected. After 6 sessions, their once a month maintenance session was resumed as the patient reported their symptoms were at the bearable level that they could perform their daily activities. The rest of the patients continued to do therapeutic exercises, and they only needed intraarticular electrical stimulation treatment when they had an unexpected increase in their level of physical activity. All of the patients stopped taking NSAID medications on regular bases, and they only took them when they had an episode of Pain due to a sudden increase in the level of physical activity or emotional stress, which was not reported more than two times in a month. None of them experienced falling in the one year. All of the scores (after 10 sessions and after the follow-up) were significant (p<0.0001).

### Table 2: Results

<table>
<thead>
<tr>
<th></th>
<th>VAS mean [0-10] (SD)</th>
<th>WOMAC mean [0-96] (SD)</th>
<th>Physical activity (Exercise and walking) [minutes per day] (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before treatment</td>
<td>7.11 (0.78)</td>
<td>79.17 (1.74)</td>
<td>0</td>
</tr>
<tr>
<td>After 10 sessions</td>
<td>4.76 (0.90)</td>
<td>72.29 (2.93)</td>
<td>35.58 (7.26)</td>
</tr>
<tr>
<td>1 year followup</td>
<td>4.11 (0.85)</td>
<td>70.82 (2.83)</td>
<td>60.88 (10.49)</td>
</tr>
</tbody>
</table>


After treatment, patients reported that their Pain had become localized. 14 cases reported that the concentration of Pain was more in the medial aspect of the joint line, especially during walking, which could be because of the high medial contact loads in the early stance phase (Kumar et al., 2013). However, all of the cases became able to at least perform their personal activities by themselves. It could be said that making these patients independent enough to take care of their basic personal activities is one of the most important achievements, and it has a great impact on their quality of life.

### 4.2 Discussion

Knee osteoarthritis could be defined as a progressive degenerative disease with a low possibility of regression and repair in damaged parts of the joint (Page et al., 2011). So all the modalities and interventions for the management of this condition are only for controlling the symptoms of patients and improving their quality of life (Mora et al., 2018). This report concentrates on the possible ways of managing symptoms of this condition and promoting their ability to perform physical activities in patients who are suffering from advanced stages of osteoarthritis, but since they have multiple comorbidities, some systemic medications and surgical procedures are not recommended for them. Physical interventions can be the chosen treatment for this group of patients since there are no adverse effects and there is no limitation for long-term use, unlike most medications that have adverse effects on gastrointestinal, renal, cardiac, and hematological systems (Mora et al., 2018). The most important part of physical treatment is a therapeutic exercise, and there are strongly recommended (both land and water-based exercises) (Mora et al., 2018. Rooij et al., 2017). But when patients’ osteoarthritis is so advanced that they are not capable of performing these exercises because of their high level of Pain and stiffness, what is the solution?

In this report, we investigated the influence of a new intervention that contains applying electrical stimulation into the knee joint directly using needles for patients with grade 4 knee OA (according to the Kellgren and Lawrence criteria) who did not respond well to other nonsurgical interventions and are not capable of performing therapeutic exercise because of advancement of pain level and stiffness. All of the patients responded well based on their VAS and WOMAC scores before and after the treatment, and this improvement remained after a one-year follow-up. It must be added all of them had several maintenance treatment sessions. One of the most important achievements of this method was that all of the patients became capable of performing therapeutic
exercises, which could be one of the reasons that they experienced an improvement in performing physical activities. This achievement raised from 0 minutes to 60.88 (± 10.49) minutes in one year. They also reported and showed a noticeable reduction in their fear of falling and became able to walk more confidently.

Another important note is that in patients with advanced knee OA, other conditions might affect patients’ inability to perform physical activity and Pain in the lower extremities. Although patients with neuromuscular conditions that might affect lower limbs were excluded, cardiovascular diseases also might affect the patients’ ability to perform physical activity. Since one of the most important contraindications of surgery is cardiovascular diseases, and they are the target group for this treatment, exercise prescription must be very careful. It must be acknowledged that none of the patients were healed completely, and all of them still had symptoms of knee OA since the best treatment for patients with this advancement in knee OA only could be a surgical procedure. It is only could be recommended for patients who are not a candidate for surgery because of other comorbidities or for patients who refuse surgery for any reason. Future studies and research is needed to confirm the effectiveness and mechanism of this method.

5. Conclusion
In this report, a noninvasive method for managing Pain and stiffness in patients with severe knee OA who could not perform the exercise and whose physical activity was reduced and also were not candidates for surgical treatment was investigated. Based on this report, it could be concluded that this method is effective in the reduction of Pain and stiffness in patients with severe knee OA, and this leads to improvement in their ability to perform therapeutic exercise and their activities of daily living. This method cannot be a substitute for surgical treatment, but it can improve the quality of life in patients that cannot have surgery. This study has its limitation since it is a report of a not randomized small sample with no control group. A randomized controlled trial for comparing this intervention with conventional treatment and investigating the results of combining it with other methods is recommended.

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Informed consent: All of the participants provided an informed written consent form.

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