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ORIGINAL ARTICLE

Comparative Study of the Effectiveness of Therapeutic Ultrasound *vs* Interferential Therapy to reduce Pain and improve Functional Ability in Osteoarthritis of Knee

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ABSTRACT

Many people develop functional limitation due to pain of osteoarthritis (OA) of the knee. Different physiotherapeutic modalities are commonly used to give treatment for patients with OA knee. This study aims to examine the efficacy of therapeutic ultrasound (UST) *vs* interferential therapy (IFT) to reduce pain and to improve functional ability in OA knee. Thirty subjects with a mean age of 62.55 ± 6.25 years having clinical diagnosis of OA of knee were randomly allocated to two study groups, namely groups I and II, each of 15 patients. Group I received UST and therapeutic exercise and group II received IFT and same therapeutic exercise designed for OA knee, conducted five times a week for 2 weeks. The outcome of this intervention was measured in terms of Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, pain relief in terms of visual analog scale (VAS), and active range of motion (ROM). It was concluded that IFT could be the better choice of modality than UST in the management of OA of knee.

Clinical significance: This study helped us to formulate a better therapeutic approach of OA of knee.

Keywords: Interferential therapy Western Ontario and McMaster Universities Osteoarthritis Index, Knee, Osteoarthritis, Physiotherapeutic intervention, Therapeutic ultrasound, Visual analog scale.

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INTRODUCTION

Osteoarthritis is the most common articular disease worldwide and commonest causes of disability of elderly populations.[1,2] Osteoarthritis is considered to be the most common rheumatologic disease which affects more than 80% of the population above 55 years. It is a complex, multifaceted condition that has been characterized by various criteria including pathogenesis (mechanical, biological), morphology (articular cartilage, subchondral bone), and clinical features (joint pain, stiffness, tenderness, loss of ROM, crepitus, and inflammation/effusion).[1,3,4] Efficacy of UST and IFT is of particular interest, as this is the physical agent most commonly used by physiotherapists for the treatment of painful musculoskeletal conditions and, therefore, widely available.[2-6] Electrotherapeutical modalities of rehabilitation are important resources in the treatment of musculoskeletal pain.[4,7] This study was done to find out the single effective physiotherapy intervention between commonly used physical modalities of UST and IFT, along with therapeutic exercise in the treatment of OA of knee.

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MATERIALS AND METHODS

Study Area: Department of Physical Medicine and Rehabilitation, Institute of Post Graduate Medical Education & Research, Kolkata, India, from July 2016 to December 2016.

Study Population: Patients diagnosed with knee OA by the PMR department of the hospital. Thirty patients were randomly selected from the population for the study and they were assessed and divided into two groups (groups I and II). Group I contained 15 subjects and group II contained 15 subjects.

Inclusion Criteria

- *Age*: 50 to 80 years
- Both sexes included
- Unilateral knee joint involvement
- Fulfillment of the American College of Rheumatology criteria for OA of the knee
- Fulfillment of the Kellgren–Lawrence[2] scores grade II–IV
- Duration more than 6 months

Exclusion Criteria

- Presence of metabolism-related arthritis (calcium deposition, acromegaly)

- Arthritis related to trauma (major joint trauma)
- Presence of inflammatory disorders (rheumatoid arthritis, ankylosing spondylitis, septic arthritis)
- Previous surgical knee intervention
- Intra-articular injection of the knee in the previous 6 months
- Presence of a traumatic episode in the affected knee
- Patient of neuropathic arthopathy, Paget disease, avascular necrosis, Wilson disease of knee joint

Study Period: 6 months

Sample Size: Thirty patients were randomly selected based on criteria for the study and they were assessed and divided into two groups, namely groups I and II, each of 15 patients.

Sample Design: This was a convenient sampling method: simple random sampling.

Study Design: It was a randomized clinical trial, comparative study.

Parameters to be Studied

- Pain—VAS scale
- Functional ability—WOMAC
- Knee ROM—By use of goniometer[4]

Study Tools: (a) IFT machine, (b) ultrasound machine, (c) quadriceps table, (d) goniometer, (e) measuring tape, (f) weighing machine, (g) statistical tools—computer, calculator

Study Techniques

Group I: Received UST and therapeutic exercise designed for OA knee.[8-10]

Ten sessions of ultrasound (1 MHz, continuous wave, 1 W/cm^2) program were conducted 5 times a week for 2 weeks, excluding weekends, for a total of 10 sessions, with each session of 10 minutes.[3,11]

Group II: Received IFT and therapeutic exercise designed for OA knee

Four interferential pad electrodes will be placed around the affected knee joint for 10 sessions, 5 times a week for 2 weeks. The patient was explained that he/she will feel a tingling sensation which should not be unpleasant.

Interferential dose: Frequency = 4000 Hz, base = 90 Hz, sweep = 40 Hz, beat frequency = 90 to 130 Hz, quadripolar, duration = 10 minutes, IFT output intensity was increased until the "normal" tingling was encountered by the patient.[7]

Both groups I and II patients received same therapeutic exercises recommended for OA knee.[12] (1) isometric quadriceps exercises, (2) active ROM exercises, (3) straight leg rising exercises, and (4) Hamstring stretching exercise. All aforementioned exercises were done with 20 repetitions on each leg, with sufficient rest to minimize fatigue.

Both groups I and II patients received the instructions regarding the things a patient with OA knee should avoid strictly: Squatting on the ground, using Indian toilets, jogging and long walks, kneeling, stair climbing, unnecessary bending, standing for long time, and carrying heavy weights.

Analysis of Data—Data analysis was done by t-test (GraphPad Prism software) statistical tools.

Pain Intensity

Measured by means of VAS. A 10 cm line marked with numbers 0 to 10 was used where 0 symbolized no pain and 10 was maximum pain. Patient was asked to mark his pain on this line.

WOMAC Scale

Western Ontario and McMaster Universities Osteoarthritis Index scale has 17 items divided into three sections (A, B, C), i.e., section A for pain, section B for stiffness, and section C for functional difficulty. Subjects were asked to rate their score out of five grades of severity, i.e., no pain, mild pain, moderate pain, severe pain, and extreme pain.

Knee ROM

Knee ROM for both flexion and extension was measured with the goniometer for both active and passive ROMs.

PROCEDURE

All the subjects with pain in the knee joint and clinically diagnosed with having chronic OA of knee were screened after finding their suitability as per the inclusion and exclusion criteria and were requested to participate in the study. The subjects willing to participate in the study were briefed about the nature of the study and the intervention. After briefing them about the study, their informed written consent was taken. The demographic data like age, sex, height, weight, occupation, and address were collected. Joint involved and duration of the symptoms were noted. Initial evaluation for their pain profile using VAS was taken. Knee joint ROM was measured by using goniometer. Flexion and extension range was measured for both active and passive range prior to the treatment. Western Ontario and McMaster Universities Osteoarthritis Index scores were taken by asking the questions to the subjects about their pain, stiffness, and functional independence. Active and passive range of movement for knee was measured with subjects in prone lying with goniometer axis coinciding with the knee joint axis at the lateral aspect of the knee. Subjects were asked to perform active knee flexion

and extension to the maximum range available and ranges were noted. After this, the joint was moved passively for both flexion and extension and ranges were noted.

RESULTS

Statistical analysis was done using the statistical software GraphPad Prism, version 5, so as to verify the results obtained, and tests for significance, such as paired t-test and unpaired t-test were utilized for this purpose.

Paired t-test was used to compare the difference of VAS, active ROM (AROM) and passive ROM (PROM), and WOMAC index before and after the treatment within each group, while unpaired t-test was used to measure the difference between the two groups in terms of decrease in VAS, improvement in AROM and decrease in the knee pain, and stiffness and improved functional ability by WOMAC index. Comparisons between the two groups were made in terms of sex distribution, age, height, body mass index (BMI), and duration of symptoms.

Age of the subjects in this study was between 50 and 80 years (Table 1). The average age of the subjects in group I (UST) was 61.5 ± 6.414 years and group II (IFT) was 63.6 ± 5.96 years.

There were 15 subjects in each group: group I (UST) had 7 males and 8 females, and group II (IFT) had 8 males and 7 females, so there were total 15 males and 15 females in each group (Table 2).

Demographic Profile (Body Weight and Height and BMI)

Height of the subjects in this study was between 1.5 and 1.6 m (Table 3). The average height of the subjects of group I (UST) was 1.55 ± 0.035 m and group II (IFT) was 1.54 ± 0.037 m. There was no significant difference between the heights of the subjects in the two groups (t = 0.3802 and p = 0.7067).

Body weight of the subjects in this study was between 63 and 82 kg. The mean body weight of the subjects in group I (UST) was 72.5 ± 5.011 kg, in group II (IFT) was 74.26 ± 3.93 kg. There was no significant difference between the body weights of the subjects in the two groups (t = 1.1312 and p = 0.267).

Body mass index (BMI) of the subjects in this study was between 28.7 and 32.5 kg/m^2. The average BMI of the subjects in group I (UST) was 29.5 ± 1.183 kg/m^2 and in group II (IFT) was 30.59 ± 1.152 kg/m^2. There was significant difference between the BMI of the subjects in the two groups (t = 1.4073 and p = 0.1703).

Duration of symptoms of subjects in this study ranged between 2 and 5 years. Mean duration of symptoms of group I (UST) was 3.8 ± 0.94 years, and of group II (IFT) was 4.13 ± 1.06 years. There was no significant difference between the duration of the subjects in the two groups (t = 0.9021 and p = 0.6253).

Pain Relief (Mean Changes in VAS Score)

Pain relief was recognized by reduction in VAS score (Table 4). For this, VAS score was noted on the first day and the last day (14th day) of the treatment for all the subjects. However, the difference between the two scores was considered for analysis of difference between the two groups. The average VAS score in group I (UST) on 1st day was 7.45 ± 0.64, which was reduced to an average of 4.2 ± 0.56 on 14th day of treatment. Mean difference between 1st and 14th day scores was 3.27 ± 0.458. The difference was found to be statistically significant (t = 27.6,

Table 1: Age distribution

Age (years)	*Group I (UST)*	*Group II (IFT)*
50–60	8	7
61–70	5	6
71–80	2	2

Table 2: Sex distribution

Groups	*Male*	*Female*	*Total*
Group I (UST)	7	8	15
Group II (IFT)	8	7	15
Total	15	15	30

Table 3: Demographic profile (body weight and height and BMI)

	Age (years)		*Height (M)*		*Body weight (kg)*		*BMI (kg/m^2)*		*Duration of symptoms*	
Groups	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Group I (UST)	61.5	6.41	1.55	0.035	72.5	5.011	29.5	1.183	3.5	0.94
Group II (IFT)	63.6	5.96	1.54	0.037	74.2	3.93	30.59	1.152	4.1	1.06

SD: Standard deviation

Table 4: Pain relief (mean changes in VAS score)

	Pretreatment		*Posttreatment*		*Mean difference*				
Groups	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*	*Inference*
Group I (UST)	7.45	0.64	4.2	0.56	3.27	0.458	27.6	0	SS
Group II (IFT)	7.47	0.516	3.13	0.64	4.33	0.617	27.2	0	SS

t = 5.342, p < 0.0001; SD: Standard deviation; SS: Statistical significance

p = 0.000). The average VAS score in group II (IFT) on 1st day was 7.47 ± 0.516, which was reduced to an average of 3.13 ± 0.64 on 14th day of treatment. Mean difference between 1st and 14th day scores was 4.33 ± 0.617. The difference was found to be statistically significant (t = 27.2, p = 0.000). The mean difference between groups I and II was calculated by t-test (t = 5.342, p < 0.0001). By conventional criteria, this difference is considered to be extremely statistically significant. Although both UST and IFT showed statistically significant improvement in reducing pain in treatment of OA knee, IFT showed better pain relief than UST.

Mean Changes in Knee Pain, Stiffness, Functional Ability in WOMAC Index

Reduction in the pain and stiffness and improvement in functional abilities were indicated in terms of reduction in WOMAC score (Table 5). For that, initial and final scores were noted on 1st and 14th day of treatment of all the subjects.

In group I (UST), the average WOMAC score on 1st day was 57.5 ± 5.90, which was reduced to 32.4 ± 3.36 on the 14th day of treatment. Mean difference between 1st and 14th day scores was 25.1 ± 4.09. The difference was found to be statistically significant (t = 23.8, p = 0.000). In group II (IFT), the average WOMAC score on 1st day was 58.7 ± 5.81, which was reduced to 26.5 ± 4.75 on the 14th day of treatment. Mean difference between 1st and 14th day scores was 32.2 ± 3.97. The difference was found to be statistically significant (t = 31.4, p = 0.000). The mean difference between group I (UST) and group II (IFT) was calculated by unpaired t-test. The two-tailed p-value was less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant. Although both UST and IFT show statistically significant improvement in reducing knee pain, stiffness, functional ability on WOMAC index in treatment of OA knee, transcutaneous Electrical Nerve Stimulator showed the better improvement (on WOMAC score) than UST.

Improvement in AROM Flexion

In group I (UST), pretreatment 1st day average range was 112 ± 7.51 and on last day it was 117 ± 4.93, and mean difference between 1st and 14th day was –5.00 ± 5.35 (Table 6). The difference was statistically significant (t = –3.62, p = 0.003).

In group II (IFT), pretreatment average range was 109 ± 8.95 and on last day it was116 ± 8.42, and mean difference between 1st and 14th day was –7.00 ± 6.49. The difference was statistically significant (t = –4.18, p = 0.001).

The mean of group I minus group II was (calculated by unpaired t-test) 2.00. By conventional criteria, this difference is considered to be not statistically significant (p = 0.3649), but group II (IFT) shows more improvement (in mean difference) in active range of knee flexion.

Improvement in AROM Extension

In group I (UST), pretreatment average range was –2.87 ± 3.44 and on last day it was –0.66 ± 1.76, and mean difference between 1st and 14th day was –2.20 ± 2.48 (Table 7). The difference was statistically significant (t = –3.43, p = 0.004).

Table 5: Mean changes in knee pain, stiffness, functional ability—WOMAC index

	Pretreatment		*Posttreatment*		*Mean difference*				
Groups	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*	*Inference*
Group I (UST)	57.5	5.90	32.4	3.36	25.1	4.09	23.8	0	SS
Group II (IFT)	58.7	5.81	26.5	4.75	32.2	3.97	31.4	0	SS

t = 4.824, p < 0.0001; SD: Standard deviation; SS: Statistical significance

Table 6: Improvement in AROM flexion

	Pretreatment		*Posttreatment*		*Mean difference*				
Groups	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*	*Inference*
Group I (UST)	112	7.51	117	4.93	–5.00	4.09	–3.62	0.003	SS
Group II (IFT)	109	8.95	116	8.42	–7.00	6.49	–4.82	0.001	SS

t = 0.9209, p = 0.3649; SD: Standard deviation; SS: Statistical significance

Table 7: Improvement in AROM extension

	Pretreatment		*Posttreatment*		*Mean difference*				
Groups	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*	*Inference*
Group I (UST)	–2.87	3.44	–0.66	1.76	–2.20	2.48	–3.43	0.004	SS
Group II (IFT)	–4.53	4.67	–1.93	2.46	–2.60	2.59	–3.89	0.002	SS

t = 0.4320, p = 0.6690; SD: Standard deviation; SS: Statistical significance

Table 8: Improvement in PROM flexion

	Pretreatment		Posttreatment		Mean difference				
Groups	Mean	SD	Mean	SD	Mean	SD	t-value	p-value	Inference
Group I (UST)	117	5.67	120	4.54	–2.93	2.74	–4.15	0.001	SS
Group II (IFT)	114	9.09	119	7.71	–4.73	1.83	–10.0	0	SS

t = 2.1158, p = 0.0434; SD: Standard deviation; SS: Statistical significance

Table 9: Improvement in PROM extension

	Pretreatment		Posttreatment		Mean difference				
Groups	Mean	SD	Mean	SD	Mean	SD	t-value	p-value	Inference
Group I (UST)	–1.2	2.57	–0.66	1.76	–0.667	1.76	–2.25	0.041	SS
Group II (IFT)	–2.4	3.18	–0.66	1.76	–1.73	2.28	–2.94	0.011	SS

t = 1.4294, p = 0.1640; SD: Standard deviation; SS: Statistical significance

In group II (IFT), pretreatment average range was –4.53 ± 4.67 and on last day it was –1.93 ± 2.46, and mean difference between 1st and 14th day was –2.60 ± 2.59. The difference was statistically significant (t = –3.89, p = 0.002). The mean of group I minus group II was (calculated by unpaired t-test) 0.4000. Interferential therapy showed better improvement in AROM extension).

Improvement in PROM Flexion

In group I (UST), pretreatment average range was 117 ± 5.67 and on last day it was 120 ± 4.54, and mean difference between 1st and 14th day was –2.93 ± 2.74 (Table 8). The difference was statistically significant (t = –4.15, p = 0.001).

In group II (IFT), pretreatment average range was 114 ± 9.09 and on last day it was 119 ± 7.71, and mean difference between 1st and 14th day was –4.73 ± 1.83. The difference was statistically significant (t = –10.0, p = 0.00).

The mean difference between groups I and II was calculated by unpaired t-test (p = 0.0434). By conventional criteria, this difference is considered to be statistically significant. Interferential therapy showed better improvement (in PROM flexion) than UST.

Improvement in PROM Extension

In group I (UST), pretreatment average range was –1.2 ± 2.57 and on last day it was –0.66 ± 1.76, and mean difference between 1st and 14th day was –0.667 ± 1.76 (Table 9). The difference was statistically significant (t = –2.25, p = 0.041).

In group II (IFT), pretreatment average range was –2.4 ± 3.18 and on last day it was –0.66 ± 1.76, and mean difference between 1st and 14th day was –1.73 ± 2.28. The difference was statistically significant (t = –2.94, p = 0.011). The mean difference between groups I and II was calculated by unpaired t-test (p = 0.1640). The mean of group I minus group II equals 1.063. Group II (IFT) showed better improvement (in PROM extension) than group I (UST).

DISCUSSION

The results of the study showed that IFT was superior to other physical modality intervention of UST in the treatment to reduce pain and to improve functional ability in OA knee.

The subjects treated with IFT showed decrease in WOMAC score at the end of 14 days (10 sessions) of intervention as compared with subjects treated with other physical modality (UST). Although both groups showed significant improvement in reducing pain and stiffness and in improving ROM of OA knee joint, IFT group showed comparatively better results.

Pain relief in subjects treated with IFT could be due to analgesic effect produced due to its action on gate control mechanism.[4-7] Pain relief was also seen in the ultrasound group, though it was less when compared with other groups. The dosage used in this study was similar to that of study done by who used continuous ultrasound waves of 1 MHz frequency and 1 W/cm^2 power. Continuous ultrasound was recommended for chronic OA of knee by the same authors.

Pain relief could be due to increased connective tissue permeability and nonthermal effect; though less understood, it can cause increased cell membrane permeability, thereby enhancing metabolic product transport. Also ultrasound is said to increase tissue temperature by generating micro-massage and stimulating healing and provide extensibility of the sonated tissues and repair of damaged tendons and soft tissues, so pain relief is substantiated, as said by Marks R, Ghanagaraja S and Ghassemi M.[13]

Interferential therapy is widely used for pain control. The rationale for this was provided by the gate control therapy of pain proposed by Melzack and Wall.[14] The input of the mechanoreceptors reduces the excitability of the nociceptor responsive cells to pain-generated stimuli, thus producing a presynaptic or segmental inhibition. Therapeutic ultrasound is frequently used in

physiotherapy clinics to treat various musculoskeletal disorders. Nonthermal effects include molecular vibration, which increases cell membrane permeability and thereby enhances metabolic product transport.[7]

Based on the present study, it could be said that IFT could be used as an effective modality in the treatment of chronic OA of the knee in terms of WOMAC score, ROM, and pain. Although UST was also found to be effective, it was not to that extent of IFT.

CONCLUSION

In conclusion, this randomized clinical trial study found that male and female subjects with clinical diagnosis of OA of the knee showed alleviation in their symptoms of pain. However, the subjects treated with IFT and UST showed an improvement in terms of pain, ROM, and WOMAC score. Hence, IFT could be the better choice of modality than UST from physiotherapy point of view in the management of OA of the knee.

Clinical Importance

This study helped us to formulate a better treatment option for management of OA of knees. By combining the two treatment modalities, none of the individual effects of the treatments are lost, but the benefit is that lower treatment intensities can be used to achieve the same results, and there are additional potential benefits in terms of outcome measures.[5]

REFERENCES

1. Hurley M. The clinical and cost effectiveness of physiotherapy in the management of older people with common rheumatological conditions. Chartered Society of Physiotherapy (March 2002).
2. MacIntyre NJ, Busse JW, Bhandari M. Physical therapists in primary care are interested in high quality evidence regarding efficacy of therapeutic ultrasound for knee osteoarthritis: a provincial survey. Scientific World J 2013 Jun;2013:348014.
3. Srbely JZ. Ultrasound in the management of osteoarthritis: part I: a review of the current literature. J Can Chiropr Assoc 2008 Mar;52(1):30-37.
4. Robertson V, Ward A, Low J, Reed A. Electrotherapy explained principles and practice. 4th ed. Heidi Harrison Publishers; 2010. pp. 167-208, 251-305.
5. Atamaz FC, Durmaz B, Comparison of the efficacy of transcutaneous electrical nerve stimulation, interferential currents, and shortwave diathermy in knee osteoarthritis: a double-blind, randomized, controlled multicenter study. Arch Phys Med Rehabil 2012 May;93(5):748-756.
6. Gundog M, Atamaz F, Kanyilmaz S, Kirazli Y, Celepoglu G. Interferential current therapy in patients with knee osteoarthritis: comparison of the effectiveness of different amplitude-modulated frequencies. Am J Phys Med Rehabil 2012 Feb;91(2): 107-113.
7. Huang MH, Yang RC, Lee CL, Chen TW, Wang MC. Preliminary results of integrated therapy for patients with knee osteoarthritis. Arthritis Rheum Arth Care Res 2005 Dec;53(6):812-820.
8. Oktayoglu P, Gür A, Yardımeden I, Calayan M, Cevik F, Bozkurt M, Em S, Uçar D, Nas K. Comparison of the efficacy of phonophoresis and conventional ultrasound therapy in patients with primary knee osteoarthritis. Erciyes Med J 2014;36(1):11-18.
9. Cakir S, Hepguler S, Ozturk C, Korkmaz M, Isleten B, Atamaz FC. Efficacy of therapeutic ultrasound for the management of knee osteoarthritis. Am J Phys Med Rehabil 2014 May;93(5): 405-412.
10. Yang PF, Li D, Zhang SM, Wu Q, Tang J, Huang LK, Liu W, Xu XD, Chen SR. Efficacy of ultrasound in the treatment of osteoarthritis of the knee. Orthop Surg 2011 Aug;3(3):181-187.
11. Sánchez A, Wakamatzu M, Zamudio J, Casasola J, Cuevas C, González A, Galicia Tapia J. Effect of low-intensity pulsed ultrasound on regeneration of joint cartilage in patients with second and third degree osteoarthritis of the knee. Reumatol Clin 2009 Jul-Aug;5(4):163-167.
12. Kisner C, Colby L. Stretching for impaired mobility. Therapeutic exercise. Philadelphia, PA: F. A. Davis Company; 2012. pp. 108-112.
13. Ultrasound for Osteo-arthritis of the Knee.A systematic review PlumX Metrics DOI: http://dx.doi.org/10.1016/S0031-9406(05)60807-3
14. Wall, Patrick D., S. B. McMahon, and Martin Koltzenburg. 2006. Wall and Melzack's textbook of pain. Philadelphia: Elsevier/Churchill Livingstone. 15th ed.