Clinical evaluation of the effects of whirlpool on patients with Colles' fractures

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A clinical trial was conducted to investigate the efficacy of the whirlpool bath in the treatment of patients with Colles' fractures. The subjects were 24 patients, male and female, aged 40 to 80 years, who were referred to a physiotherapy department for treatment of a Colles' fracture with no other associated condition. The subjects were randomly assigned to one of two treatment groups—"whirlpool" or "towel"—following the immobilization phase. Patients in the whirlpool group (n = 12) had their hand, wrist and forearm immersed in the whirlpool for 15 minutes while, in the towel group (n = 12), patients had their hand and wrist wrapped in two towels (at room temperature) for 15 minutes. Following treatment by either modality, both groups of patients received a standard treatment of massage, joint mobilization, and active and resisted exercises. No occupational therapy was given. Pain, oedema, range of motion and strength were measured by independent evaluators before and after the application of the modality. Data were collected over a maximum period of 12 treatment sessions. While whirlpool patients experienced a significant increase in oedema on a short-term basis, no significant long-term differences between the two methods of treatment with regard to pain, oedema, range of motion or strength were noted. Until more definitive evidence on the benefits of whirlpool is provided, the common practice of using the expensive modality of whirlpool baths for the treatment of Colles' fractures post-immobilization is debatable.

KEY WORDS: Colles' fracture, hydrotherapy, clinical trial

Une évaluation clinique de l'utilisation des bains tourbillon a été menée afin de vérifier leur efficacité dans le traitement des patients ayant subi une fracture de Colles. Vingt-quatre patients, hommes et femmes, âgés de 40 à 80 ans, ont été examinés. Ils avaient tous été référés à un service de physiothérapie à la suite d'une simple fracture de Colles, sans autre problème connexe. Les patients ont été répartis au hasard en deux groupes: le premier devant être traité à l'aide de bains tourbillon, et le second à l'aide de serviettes humides. Les patients du groupe "bains tourbillon" (n = 12) ont eu la main, le poignet et l'avant-bras immergés dans un bain pendant 15 minutes, tandis que ceux du groupe "serviettes" (n = 12) ont eu la main et le poignet entourés de deux serviettes (à la température de la pièce) pendant 15 minutes. Quel que soit le mode de traitement utilisé, chaque patient recevait ensuite le protocole habituel comprenant massages, mobilisation de l'articulation et exercices actifs et résistés. La thérapie occupationnelle n'a été utilisée en aucun cas. La douleur, l'oedème, l'amplitude de mouvement et la force ont été mesurés par des évaluateurs indépendants avant et après chaque traitement. Les données recueillies couvrent une période maximum correspondant à une série de 12 traitements. Quoique les patients du groupe "bains tourbillon" aient éprouvé, à court terme, un oedème nettement plus prononcé que les autres, aucune différence significative n'a pu être relevée, à long terme, entre les deux méthodes de traitement tant du côté de la douleur que de la force, de l'oedème ou de l'amplitude de mouvement. Tant qu'on ne parviendra pas à obtenir de l'utilisation des bains tourbillon, des résultats plus probants, le débat entourant la pratique courante qui consiste à les utiliser dans le traitement des fractures de Colles demeurera ouvert.

One of the commonly used modalities in physical therapy today is the whirlpool bath.[1] Since its introduction in France for the treatment of post-traumatic conditions during World War I,[2] the whirlpool has become a popular modality in physical therapy for the treatment of various conditions, one of which is the Colles' fracture post-immobilization.

Colles' fracture is defined as a fracture occurring within one inch of the lower end of the radius, with a posterior tilt, posterior displacement and radial deviation of the distal fragment which may or may not be comminuted.[3] On removal of the cast, usually six to eight weeks post-reduction, there is often stiffness, pain, swelling and weakness in the forearm and hand. Generally speaking, these symptoms are dependent on the severity of the fracture, age of the patient, motivation of the patient, and length of immobilization.

The whirlpool bath is often used for patients with Colles' fractures as an adjunct to exercise. The aim of this treatment is to decrease pain and relax stiff joints prior to the exercise program;[4] yet the efficacy of this commonly employed therapeutic procedure remains unknown.

Magness et al[5] reported adverse effects of the whirlpool on the upper extremity, concluding that an increase in oedema occurred due to the dependent position of the arm and the high temperature of the water. Stillwell[6] supported the idea of the increased oedema effect, and claimed that it was due to an increased capillary flow. Walsh,[7] in 1983, concluded from his study on the effects of whirlpool bath on normal subjects, that a water temperature of 40°C significantly increases hand volume. He noted, however, that the position of the upper extremity in the whirlpool bath had no significant effect on hand volume. On the other hand, Pope[8] suggested that the heat and massage of the turbulent water of the whirlpool has a relaxing effect on muscles, which leads to joint pliability. To date, no clinical trial to evaluate objectively the use of the whirlpool in the treatment of patients with Colles' fractures has been conducted.

The aim of this study is to evaluate the efficacy of the whirlpool for Colles' fracture patients. A clinical trial was designed to investigate the impact of the whirlpool bath on pain, oedema, range of motion, and strength of the hand and wrist of Colles' fracture patients post-immobilization.

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Method

A clinical trial was conducted in an acute care general teaching hospital, where patients with Colles' fractures are rehabilitated by physical therapists experienced in the treatment of hand and wrist injuries. The subjects selected were patients who had been referred to the department of physical medicine with a Colles' fracture of either wrist, and with no associated fractures or conditions, such as shoulder-hand syndrome, rheumatoid arthritis, or brachial plexus injuries. The subjects had undergone closed reduction and were not immobilized for longer than eight weeks. Subjects did not receive occupational therapy for the involved hand and all signed an informed consent form prior to entering the trial.

Twenty-four subjects (20 women and 4 men, between 40 and 80 years of age) were admitted to the trial and were randomly assigned to one of two treatment groups, either "whirlpool" or "towel". (See Table 1 for subjects' characteristics.) Patients assigned to the whirlpool group were treated in a seated position with the affected forearm and hand immersed in the whirlpool bath and the elbows flexed at 90° for 15 minutes.

The equipment used was a standard motor mobile whirlpool*, featuring an electric turbine ejector and aerator with 1/3 hp and a high speed 3450 rpm motor. The underwater stream was set at the maximum intensity, directed towards the centre of the pool. The water temperature was maintained between 37.8°C and 43.3°C, and the disinfectant Proviodine Hydro (Rougier) was added daily to the water upon filling the bath.

Patients assigned to the towel group were seated with the forearm and hand supported on a pillow and wrapped with two standard hospital towels (at room temperature). The elbow was flexed at 90° and the treatment time was 15 minutes.

Following application of either modality, the subjects of both groups were treated by the investigators with: massage (effleurage) of the hand and forearm in the elevated position for five minutes; joint mobilization, as per Kaltenborn;[9] active range of motion exercises; and progressive resisted exercises for the elbow, wrist and fingers, in accordance with the healing status of the bones. Total treatment time for each subject was 45 minutes per session.

Each treatment session was given twice weekly until a) 12 sessions were completed; or b) the patient considered him/herself functional prior to the completion of the 12 sessions and decided that he/she no longer required therapy; or c) the therapist considered the patients functional prior to the completion of the 12 sessions and discontinued treatment.

If the patients did not improve and an alternate or additional form of therapy was warranted, or if the patient worsened, he/she was removed from the trial and referred to an appropriate source of treatment.

Assessments by independent evaluators (who were unaware of the patient's group assignment) were performed prior to and following each whirlpool or towel treatment. Due to the obvious signs of the whirlpool therapy (redness and wrinkling of the skin), the subjects of both groups were asked to wait an additional five minutes before returning to the evaluator to be reassessed.

The dependent variables assessed by the evaluators included pain, range of motion (ROM), oedema and grip strength. Pain was measured by the Present Pain Intensity (PPI) scale from the McGill Pain Questionnaire.[10] This scale ranks the degree of pain from "no pain" to "excruciating" (0-5), giving a quick, quantitative and objective measure of pain.

Range of motion of the affected forearm (pronation and supination), wrist (flexion, extension, ulnar deviation and radial deviation), and fingers (thumb, index, long, ring, and little MCP flexion), were measured using standard wrist and finger goniometers, according to the guidelines presented by the American Academy of Orthopedic Surgeons[11] with several modifications (see Appendix).

Oedema in the wrist and hand was determined by using a standard volumeter. The patient rested the third web space of his/her hand on a 10.5 cm by 12 cm upright sheet of plexiglass (in the tank) while the forearm lay against the corner of the tank. The water, originally filled to the rim of the spout, was displaced through the spout and flowed into a graduated cylinder to measure the volume of the forearm and hand (Archimedes' principle). A similar tank was described by Eccles[12] and Smyth et al[13] and found to be reliable by a margin of error of less than one percent.

Grip strength was measured by a Jamar grip dynamometer† with adjustable hand spacing. This instrument uses a sealed hydraulic system which registers force in pounds or kilograms.[14] Reynold et al[15] recognized the Jamar dynamometer as the most acceptable instrument on the market for a quantitative measurement of grasping power. The subjects in the trial were asked to make a maximal effort in squeezing the dynamometer (with the hand-grip spacing set at 5 cm) while the elbow was extended and the shoulder was flexed at 90°.

The evaluators who were used throughout the trial had achieved an inter-rater reliability of 0.80 or better on all the assessment measures with the exception of metacarpophalangeal (MCP) flexion of the ring finger ($r = .67$) and little finger ($r = .77$) and wrist radial deviation ($r = .71$).

Statistical analysis

Chi square analyses were performed to compare the two groups on a variety of potentially confounding variables: sex, hand dominance, type of fracture, and type of cast. In addition, *t*-tests were performed to analyze pre-existing group differences such as age, period of immobilization, period between cast removal and commencement of therapy, and pre-scores on all the outcome variables.

Individual *t*-tests were performed on the post-scores to analyze the effects of both treatments, both long-term (over all the sessions) and short-term (immediately following the modality). The values analyzed for the long-term effects were the post-scores of the last session of treatment. Short-term effects were analyzed by randomly selecting one treatment session and performing *t*-tests on the post-scores.

Results

No significant pre-existing differences between the potentially confounding variables of the two groups were found. (See Tables 1 and 2 for descriptions of group characteristics).

No significant long-term group differences were found on any of the post-treatment scores with the exception of MCP flexion of the long finger ($p = 0.02$). Patients in the whirlpool group had significantly less long MCP flexion (see Table 3).

As for short-term differences, patients in the whirlpool group had significantly more oedema ($p = 0.04$) and less index MCP flexion ($p = 0.04$) immediately following treatment than those who received the towel treatment. No other short-term changes were significant (see Table 4).

T-tests on change scores (post minus pre) revealed no significant differences between the two groups on any of the dependent variables.

Paired *t*-tests for all 24 subjects were performed to compare the pre-scores of the first session and the post-scores of the last session. Significant improvement on all of the dependent variables was noted over the treatment period regardless of the group assignment.

**Whirlpool bath model HM285, Ille Electric Corporation, Williamsport, PA 17701, USA*

†Jamar dynamometer, model #14682, Asimow Engineering Company, Santa Monica, CA 90404, USA.

Table 1

Characteristics of subjects in whirlpool and towel groups (n = 24)

CHARACTERISTICS	Whirlpool (n = 12)	Towel (n = 12)	X^2	P value
PHYSICAL FACTORS				
Sex				
Males	1	3	0.30	0.58
Females	11	9		
Dominant hand affected				
Yes	11	12	0.00	1.00
No	1	0		
Type of fracture				
Distal radius, undisplaced	2	4	2.79	0.43
Distal radius, displaced	5	2		
Distal radius & ulna	2	1		
Comminuted distal radius & ulna	3	5		
Type of Cast				
Above elbow, MCPs excluded	1	0	3.87	0.57
Above elbow, MCPs included	1	1		
Below elbow, MCPs excluded	4	4		
Below elbow, MCPs included	2	0		
Combination, MCPs excluded	2	4		
Combination, MCPs included	2	3		
TEMPORAL FACTORS				
Age (mean years ± SD)	62.25 (±7.86)	57.08 (±4.93)	—	0.07
Immobilization period (mean weeks ± SD)	5.83 (±1.34)	5.92 (±0.90)	—	0.86
Post-cast to therapy period (mean days ± SD)	6.25 (±3.31)	6.67 (±1.56)	—	0.70

Discussion

Our findings fail to demonstrate major long-term significant differences between the patients receiving whirlpool and those treated with towels on any of the post-scores of the variables. The long-term improvement of MCP flexion of the long finger following the towel application, while statistically significant, has little clinical importance because there was no marked improvement in MCP flexion for the remaining digits. Similarly, the short-term significant difference between the two groups in the MCP flexion of the index finger may also be of questionable clinical importance.

The short-term difference between the two groups in the amount of oedema experienced, however, is worth noting. Patients receiving whirlpool therapy immerse their forearm in the whirlpool bath in a dependent position, which appears to increase oedema formation. Patients with moderate to severe hand oedema prior to treatment may, indeed, experience a worsening of this condition immediately following the whirlpool therapy. The subjects in the whirlpool group did have significantly more forearm and hand oedema immediately following the whirlpool bath than did the subjects in the towel group. Yet the increased oedema did not result in a corresponding decrease in ROM or strength, or a corresponding increase in pain. In addition, because no long-term differences between the groups were noted, one may assume that no detrimental effects occurred as a result of the increased oedema. This supposition was supported in a recent study by Hoyrup and Kjorvel[16] in which they compared the effects of wax and whirlpool baths on pain, ROM, and oedema in 42 male subjects being treated for traumatic hand injuries. An increase in hand volume following whirlpool baths was noted on a daily basis. Over a three-week period, however, both modalities had the same effect on hand volume and significantly improved both pain and ROM.

Due to the popularity and extensive use of whirlpool baths in departments of physical medicine since World War I, our failure to demonstrate significant improvements in patients receiving this modality is somewhat surprising. Although the absence of statistically significant results might be attributed to our small sample size and the concomitant increase in the beta error, it might also be explained physiologically. The purported physiological therapeutic effects of heat on the human body are well documented, and include: increased extensibility of collagenous tissues, decreased joint stiffness, pain relief, relief of muscle spasm, resolution of inflammatory waste products, and increased blood flow.[4]

However, to effect a change in the collagen microstructure and to enhance its viscous properties to promote long-lasting elongation, tissue temperature should be elevated to 40°C[17] (that is, 20 minutes of immersion in temperatures between 42.5 and 45°C).[18] In addition, the tight structures must be appropriately stretched at an elevated temperature.[17] Thus, for the whirlpool to be therapeutically advantageous, these principles must be considered. The absence of these critical conditions may easily explain the lack of significant improvement in ROM of the affected joints in this trial.

The use of heat for analgesia has been largely based on empirical findings. While analgesia by heat has recently been attributed to reduced secondary muscle spasm, hyperemia in tension syndromes, counter-irritance or the release of endorphins,[4] the physiological data in support of these effects are few. In this clinical trial, the subjects in the whirlpool group reported no significant pain reduction in comparison with those of the towel group.

Table 2

Pre-treatment evaluation scores of outcome variables for subjects in whirlpool and towel groups (n = 24)

Variables	Whirlpool (n = 12) Mean	SD	Towel (n = 12) Mean	SD	p level
Range of movement (degrees)					
Thumb MCP flexion	38.00	15.46	46.67	11.93	0.14
Index MCP flexion	75.08	23.22	77.08	14.22	0.80
Long MCP flexion	79.58	27.09	77.08	16.71	0.79
Ring MCP flexion	75.83	24.20	70.42	21.26	0.57
Little MCP flexion	60.00	23.65	64.58	26.41	0.66
Wrist flexion	46.67	13.54	44.17	12.94	0.65
Wrist extension	20.42	24.81	27.08	24.26	0.51
Wrist radial deviation	9.17	6.34	12.50	7.23	0.24
Wrist ulnar deviation	17.92	6.20	19.17	6.69	0.64
Forearm pronation	61.67	20.15	60.83	23.24	0.93
Forearm supination	41.17	33.07	53.75	18.72	0.26
Pain (PPI)	1.50	1.31	1.42	0.79	0.85
Oedema (mL)	584.25	83.88	544.17	79.48	0.24
Strength (kgf)	2.50	3.71	1.83	3.10	0.64

Table 3

Post-treatment evaluation scores of outcome variables (long-term) of whirlpool and towel groups (n = 24)

Variables	Whirlpool (n = 12) Mean	SD	Towel (n = 12) Mean	SD	p level
Range of movement (degrees)					
Thumb MCP flexion	49.58	12.70	55.83	9.73	0.19
Index MCP flexion	79.58	10.76	87.08	7.82	0.06
Long MCP flexion	82.92	9.16	90.42	5.42	0.02
Ring MCP flexion	82.08	12.70	87.92	5.42	0.18
Little MCP flexion	82.50	13.73	87.50	7.54	0.29
Wrist flexion	56.67	13.87	56.67	15.42	1.00
Wrist extension	43.33	13.54	48.75	21.23	0.46
Wrist radial deviation	17.50	6.23	17.92	8.11	0.89
Wrist ulnar deviation	24.58	4.50	24.58	4.98	1.00
Forearm pronation	77.92	12.52	77.92	7.82	1.00
Forearm supination	75.00	16.92	74.17	14.60	0.90
Pain (PPI)	0.42	0.52	0.67	0.89	0.41
Oedema (mL)	558.33	80.77	510.00	69.12	0.13
Strength (kgf)	6.00	5.51	7.33	5.40	0.56

Table 4

Post-treatment evaluation scores of outcome variables (short-term) of whirlpool and towel groups (n = 24)

Variables	Whirlpool (n = 12) Mean	SD	Towel (n = 12) Mean	SD	p level
Range of movement (degrees)					
Thumb MCP flexion	40.00	15.37	48.75	10.47	0.12
Index MCP flexion	68.75	12.27	79.17	11.04	0.04
Long MCP flexion	73.33	12.31	80.00	15.81	0.26
Ring MCP flexion	70.00	13.31	75.00	20.56	0.49
Little MCP flexion	64.17	20.32	74.17	23.73	0.28
Wrist flexion	52.20	14.85	47.08	12.15	0.34
Wrist extension	22.50	19.71	30.42	26.33	0.41
Wrist radial deviation	9.58	6.20	12.50	8.12	0.33
Wrist ulnar deviation	20.42	6.56	21.67	6.85	0.65
Forearm pronation	64.58	17.38	69.58	11.77	0.42
Forearm supination	51.25	26.64	53.33	20.93	0.83
Pain (PPI)	0.75	1.06	1.42	1.31	0.18
Oedema (mL)	592.50	97.13	519.58	67.84	0.04
Strength (kgf)	1.42	2.50	1.75	2.63	0.75

The psychological benefits attained by the use of whirlpool must also be considered when evaluating the popularity of this modality. Patients generally comment on the comfort and pleasant feeling derived from the turbulent action of the warm water. However, any physiological changes caused by the whirlpool bath have been attributed solely to the hot water and not to the turbulence.[5] The presence of a stainless steel tank with an attached motor is not necessarily warranted to supply the required heat therapy.

The whirlpool tank has traditionally been perceived as a physiotherapeutic intervention that may motivate the patient to attain greater ranges of motion, to perform the exercises better, and to tolerate more pain. Because our findings fail to demonstrate these effects, the use of expensive models of whirlpool tanks in physical therapy departments to effect the desired results of heat on post-immobilization Colles' fracture patients should be questioned.

Conclusion

Despite subjective clinical observations that suggest that whirlpool therapy results in pain reduction, increased ROM and increased strength, this clinical trial reveals no major long-term significant differences between subjects with Colles' fractures who received whirlpool therapy and those who received treatment with towels. Increased oedema immediately following whirlpool therapy was not significant enough to limit ROM or strength, or to increase pain. Further investigations are required to determine whether modifications in the heat application would effect positive changes.

In summary, until further research investigations provide more definitive evidence on the efficacy of the whirlpool, the common practice of using expensive whirlpools in physical therapy departments for the treatment of post-Colles' fractures is debatable.

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APPENDIX: Goniometric modifications

The following goniometers were used.

- For wrist and elbow measurements: 17-cm long, stainless steel OEC goniometer, range 0° – 180°; and
- For finger joint measurements: 10-cm G.E. Miller stainless steel, pocket goniometer; range 0° – 140°, 40° – 180° in opposite directions.

Movement	Fulcrum	Resting arm	Moveable arm	Comments
Forearm supination	Just medial to distal ulna, level with anterior wrist surface	Line of gravity	Parallel to anterior wrist surface, level of proximal wrist crease	Elbow at 90°; shoulder at neutral
Forearm pronation	Just medial to distal ulna, level with posterior wrist surface	Line of gravity	Parallel to posterior wrist surface, level of ulnar styloid	Elbow at 90°; shoulder at neutral
Wrist flexion & extension	Mid-carpal joint (ulnar aspect)	Along the ulna	Parallel to 3rd metacarpal	