Synergistic Effect of Compression Therapy and Leg Position on Patients Post Total Knee Arthroplasty Swelling, Pain and Range of Motion

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Abstract:
Background: Postoperative knee swelling and pain are common after total knee arthroplasty. The use of a compression therapy and leg position would reduce knee swelling and improve pain. **Aim:** To evaluate the synergistic effect of compression therapy and leg position on patients post total knee arthroplasty swelling, pain and range of motion. **Setting:** Orthopedic department at Assiut university hospital. **Subjects:** A convenience of 150 adult patients who randomly and equally divided into three groups (50 each) Patients encountered in the study had the following criteria: adult patients from both gender and on the day of operation. While the patient who were uncooperative or use compression therapy were excluded from the study sample. **Tools:** Patients' demographic and medical data sheet, swelling measuring scale, analogue pain scale, range of motion scale were utilized. **Results:** No statistically significant difference was found between studied groups regarding their demographic and medical data. Also, there was a significant decrease of post-operative knee swelling and improvement in range of motion degrees mainly among compression and leg position group when compared with other groups either compression therapy or leg position (P. 0.002 and 0.021 respectively). **Conclusion:** significant difference existed between all studied groups regarding swelling and range of motion degrees but no statistical significance regarding pain mean scores post total knee arthroplasty. **Recommendation:** Using compression therapy with leg exercise indorsed for total knee replacement arthroplasty patients to minimize swelling improve range of motion and prevent complications post-operatively.

Keywords: Compression Therapy, Leg Position, Pain, Synergistic Effect, Range of motion, Swelling & Total Knee Arthroplasty

Introduction

Knee replacement is a surgical procedure that relieves pain and improves quality of life in people who have severe arthritis in their knees. One of the most popular orthopedic operations is total knee arthroplasty (TKA), sometimes known as total knee replacement. Which one of the most successful orthopedic treatments. The operation has a good track record in the medical literature, with good long-term outcomes and low complication rates **(Li et al., 2020)** However, postoperative knee swelling is a common problem due to intra-articular bleeding and inflammation of periarticular tissues. This results in decreased functional performance as a result of quadriceps weakness and arthrogenic reflex inhibition due to pain which can delay rehabilitation, increase hospital length of stay and decrease patient-reported outcomes. Additionally, excessive knee swelling is associated with increased rates of wound dehiscence and infection **(Wu et al., 2020).**

This effect could be explained by three mechanisms; first of all, rising the leg helps to move blood from the lower limb vasculature, by the effect of gravity, to the intrathoracic veins, leading to an increase in cardiac preload. Secondly, straight leg raising is associated with an increased systemic vascular resistance. Lastly, with the leg elevated during deflation, the blood shift to the ischemic limb will be significantly decreased by the effect of the gravity **(Sonbol & Ghareeb, 2021).**

Compression bandage therapy is the established treatment of venous ulcers and lymphoedema. The application of this external compression aids venous return and reduces hydrostatic pressure in the leg by (1) improving the efficacy of the calf-muscle pump and (2) moving blood from the superficial to the deep venous system, subsequently allowing movement of fluid from the interstitial space. The use of inelastic bandages is preferred in arthroplasty as they have a low, tolerable resting pressure but a more effective activation of the deep venous system and calf-muscle pump with ambulation compared to their elastic counterparts **(Bjork & Ehmann, 2019).**

Staff nurses have an important role in managing and improving patient post-operative as patients' quality of life significant after TKA.

These interventions may include limb positioning, swelling reduction techniques, help patients using assistive aids as cane walker wheelchair and teaching them how to use elastic bandages and range of motion techniques postoperatively **(Guo et al., 2021).**

Significant of the study
Total knee arthroplasty alters postoperative complications, as observed by knee function and occurrence of swelling and pain **(Lei et al., 2021)**. Post-operatively, all researchers studied and performed change position only or wearing compression without standards program of care, this led to slowly improvement of knee range of motion and recovery in the post-operative period **(Cabral et al., 2019)**. Consequently, the study aimed to investigate the synergistic effect of compression therapy and leg position based on standardized program on reducing the incidence of postoperative complications, swelling and pain after total knee arthroplasty.

Operational definition:
A synergistic effect is the result of two or more processes interacting together to produce an effect that is greater than the cumulative effect that those processes produce when used individually.

The aim of the study:
To evaluate the synergistic effect of compression therapy and leg position on patients post total knee arthroplasty swelling, pain and range of motion.

Study hypotheses:
Applying of compression therapy and leg position together immediately postoperative would lead to reduce swelling and pain among patients with total knee arthroplasty.

Research design:
Quasi-experimental research design was utilized to fulfill the aim of this study.

Subjects and Methods
Setting:
The study was conducted at Assiut university hospital in the orthopedic department.

Subjects:
Convenience sample of 150 patients who were divided randomly and equally into three groups (50 each), of both sexes. Patients countered in the study had the following criteria:
Patients with 1st or 2nd time of operation in one or both legs, in the same day of operation, age ranged between 18 and less than 60 years old, regardless of their educational level were included. While the patients unable to be cooperative, use the compression therapy or maintain leg in the position properly were excluded from the study sample.

Tools of the study:
Four tools were used to collect the necessary data.
Patients' demographic and medical data sheet:
The researcher developed it after passing through an extensive and relevant review of literature **(Sonbol & Ghareeb, 2021) & (Wu et al., 2020)**.. It comprised the following items: It concerned with the demographic data; name, age, sex, & occupation moreover the clinical characteristics including height, weight (kg) to calculate the body mass index (BMI) as well as the medical date; chronic disease, history of disease and the affected limb.
### Swelling measuring scale:
By measuring circumference of each leg, with a tape measure, the investigators measured thigh circumference (10 cm above the proximal pole of the patella); knee circumference (at the center of the patella). This tool used to assess the presence of swelling in the affected limb **(Brodovicz et al., 2009).**
Range of motion scale for each leg:
The investigator used a goniometer to measure the ROM. of both knees (the superior arm aligned with the greater trochanter of the femur, the axis aligned with the middle of the patella, and the inferior arm aligned with the lateral malleolus)
The researcher measured range of motion with a goniometer. The patient was placed in the supine position with the stationary arm of the goniometer placed on the greater trochanter of the femur; the axis placed on the lateral epicondyle, and the movable arm is placed in alignment with the lateral malleolus of the ankle **(Kırkaya et al., 2021).** Flexion occurs at the hip, and the knee and the angle are measure at the knee. The range of motion was assessed at evaluation and discharge.
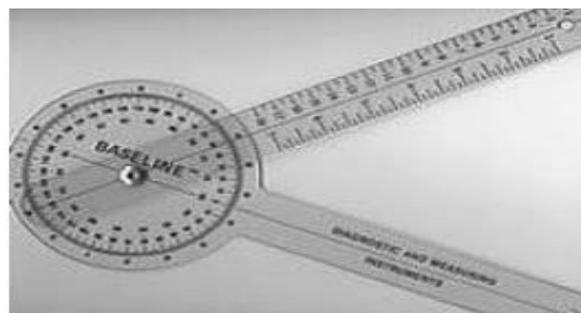
Visual analogue pain scale:
It included the worst pain in the past 24 hours and pain during physical therapy using a VAS scale of 0 (no pain) to 100 mm (worst pain possible). Patients were instructed to indicate their pain levels by marking an X on the scale, we then measured with a ruler (for the VAS pain questionnaire **(Freyd, 1923).**

The tools' **content validity** of these tools was checked by 5 expert professors in the fields of medicine and nursing and corrections were carried out accordingly.

The tool (I)' **reliability** was 0.8, using the Kuder–Richardson-19 (KR-19) formula**.**

Methods

Data collection:

Official approval letter was obtained from head of the orthopedic department and post-operative care unit at Assiut university hospital to conduct the research. Oral consent was taken from patients participate in the study after full explanation the steps of this study and its effect on patient's outcome.

Ethical Consideration

After discussing the purpose and benefits of the study, each patient signed a oral consent form. The researchers stressed that participation in the research was entirely voluntary, and that each patient had the choice to withdraw at any moment and for any reason. By coding and tabulating the data, anonymity and confidentiality were also ensured.

A pilot study: It was carried out on 10% (15 patients five from each group) of the study subjects, who added to the main study. The pilot study was done to ensure clarity, applicability, feasibility of conduction of the study tools, and time needed for each tool to be filled in minor modifications were done according to the pilot study findings.

Implementation: Through a period of full year from September 2020 to September 2021, the study was conducted. The studied patients who met the stated criteria were identified daily from first day of admission records. Additionally, data collected from the patients through interview and their files as, demographic, and medical data.

Procedures

The patients were divided into three groups: compression therapy (group 1) leg position (group 2) and (group 3) who receiving both compression therapy and leg position techniques. The study patients were met by the investigator a day before the surgery; to collect information. Collection of the information was done from nurses' records and each patient were individually to complete data collection it took about 1 hour for all tools.

For helping the studied patients to understand the practices which performed to them, the researchers gave them all instructions. So, they were able to collaborate and cooperate with them.

Patients performed compression therapy(Group 1)

Initially, the investigator explained them the steps to the patients "with assistance of physiotherapist in the study setting" and gave them a colored book which helped to understand what they did.

Compression therapy instructions:

Patients' compression bandage (group 1) received a compression bandage over the hydrocolloid surgical wound dressing instead of the routine wool and crepe bandage. A soft inner layer was applied from the toes to the groin on the affected leg with a 50% overlap of bandage. Following this, the outer compressive layer bandage was applied firmly over the top, again with a 50% overlap of bandage. The bandage was pulled to full stretch before it was wrapped around the leg to ensure adequate compression in the application. It was applied after release of the tourniquet by necessity due to its length up the thigh. To ensure homogeneity in bandage application, the nurses were shown a training video on correct application of the bandage and were given a tutorial on bandage application with real-life bandage application and feedback. The bandage was removed 24 hours post-surgery leaving the hydrocolloid wound dressing in situ. Swelling, pain and range of motion degrees assessment applied pre, post1, post 2 and post 28 days of operation

Patients performed leg position (group 2):

The patient had bilateral passive leg raising to a 45° angle that used to predict fluid responsiveness in these patients. That test based on a simple fact, raising the limb upwards would aid the blood contained in the lower limb vasculature to be auto transfused in the circulation, leading to an increase in the cardiac preload. Swelling, pain and range of motion degrees assessment applied pre, post1, post 2 and post 28 days of operation.

Patients performed both compression therapy and leg position (group 3): As previously noted, the patient took a few minutes to transition between the two activities. They stated with applying compression bandage therapy then had bilateral passive leg raising to a 45° angle

Swelling, pain and range of motion degrees assessment applied pre, post1, post 2 and post 28 days of operation. The two practices to determine the patients' tolerance with them, at the end, they reassessed as the above steps, formerly comparing them with the preceding and recorded the results.

Statistical Design

All the data was tallied and examined. For statistical analysis, SPSS software version 19 was used. Frequency and percent were used to express categorical data. The mean and standard deviation (SD) were used to express numerical data. The T-test was used to compare the three sets of numerical data that were analyzed. The Chi square test was developed to compare numerical data groups. If the P-value was less than 0.05, it was regarded significant, if it was less than 0.001 it considered highly significant, and if it was more than 0.05, it considered non-significant.

Results:

Table (1): Relation between three studied groups regarding their demographic and medical data (no=50 each group).

Characteristic	Study group The total number (150)						p. value
	Compression therapy (N = 50)		Leg position (N=50)		Compression therapy and leg position (N = 50)		
	No.	%	No.	%	No.	%	
Age (years):							
↓20	1	2.0	2	4.0	4	8.0	0.442
< 30	5	10.0	6	12.0	4	8.0	
< 40	10	20.0	11	22.0	10	20.0	
<55	34	68.0	31	62.0	32	64.0	
Mean ±SD	**46.20 ± 7.40**		**44.30 ± 6.50**		**51.20 ±4.60**		
Sex							
▪ Female	29	58.0	30	60.0	31	62.0	0.552
▪ Male	21	42.0	20	40.0	19	38.0	
Occupation							
▪ Mechanical work	13	26.0	15	30.0	12	24.0	
▪ Office work	35	70.0	32	64.0	34	68.0	
▪ Farmer	1	2.0	1	2.0	2	4.0	0.325
▪ Not work	1	2.0	2	4.0	2	4.0	
BMI Mean ±SD	**31.12±1.21**		**25.23±5.17**		**22.53±13.41**		0.288
knee pain > 5 Yrs.	23	46.0	21	42.0	20	40.0	0.352
Chronic disease							
▪ No	47	94.0	49	98.0	47	94.0	
▪ Hypertension	3	6.0	1	2.0	3	6.0	0.774
Affected limb							
▪ Right	25	50.0	31	62.0	29	58.0	
▪ Left	25	50.0	19	38.0	21	42.0	0.889

Chi square test   ** The significant level < 0.05*
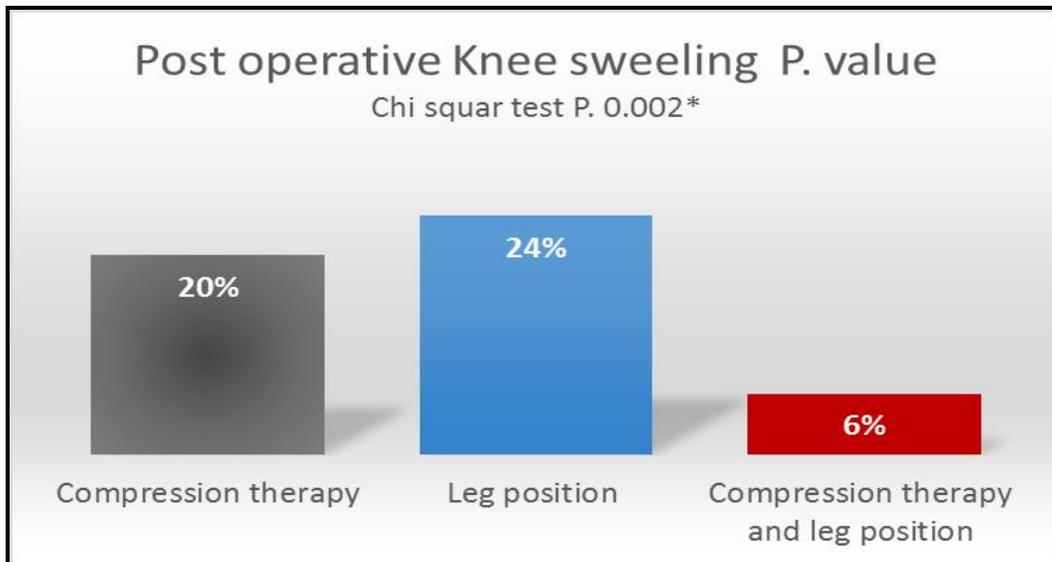
Figure (1): Relation between the three studied groups regarding Knee swelling after 28 days post operatively (each group no=50).
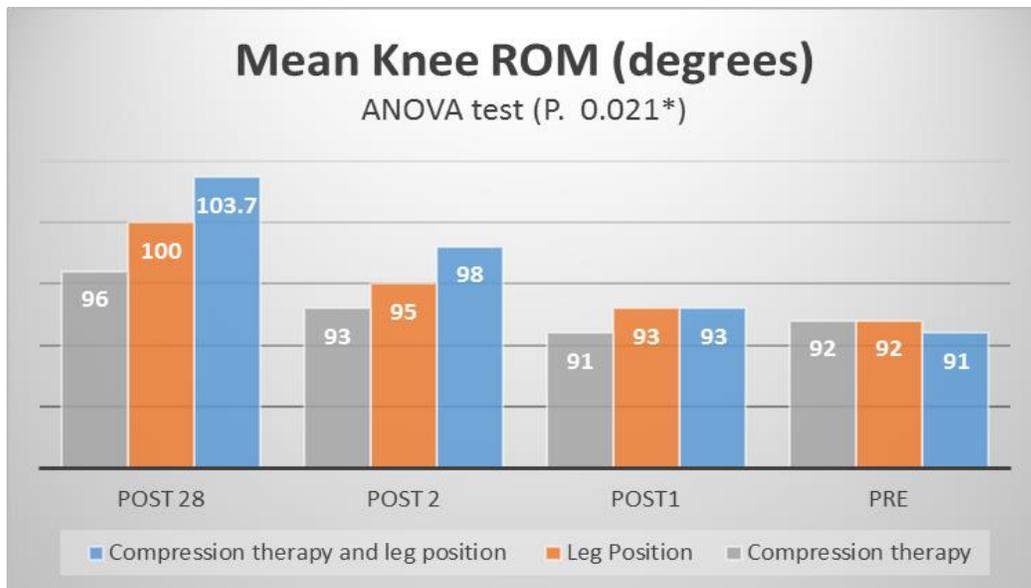
Figure (2): Comparison between three studied groups regarding mean knee range of motion degrees after 28 days of operation (each group no=50).
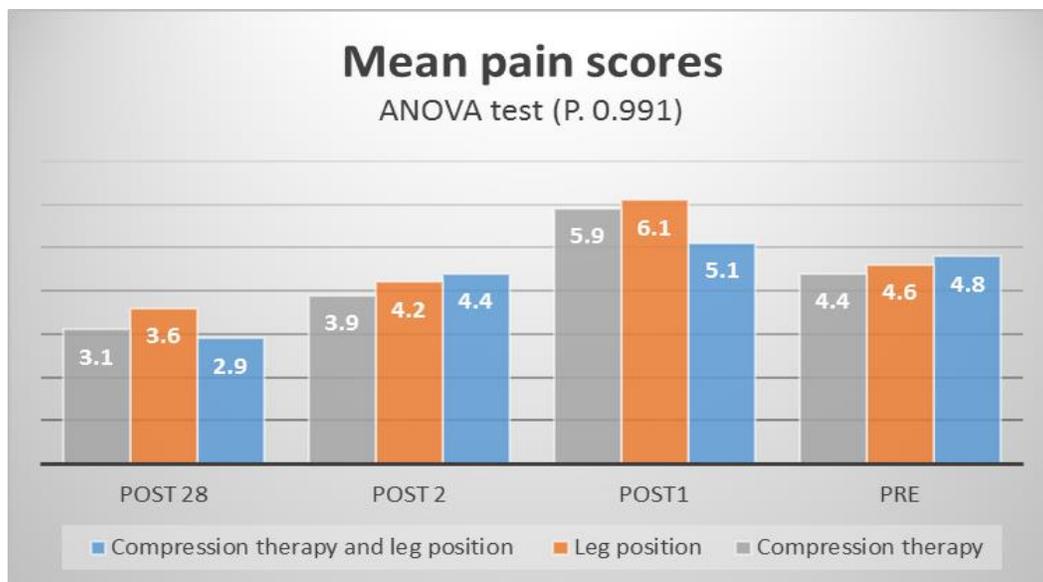

Figure (3): Comparison between three studied groups regarding mean analogue pain scores after 28 days of operation (no=50 each group).

Table (3): Correlation between BMI & patients' ages in three studied groups 28 days post operatively (each group no=50).

Items	BMI Mean ±SD	Age Mean ±SD
Compression therapy	31.12±1.21 *p<0.05**	46.20 ± 7.40 *p<0.001***
Leg position	25.23±5.17 *p<0.05**	44.30 ± 6.50 *p<0.001***
Compression therapy and leg position	22.53±13.41** *p<0.001*	51.20 ±4.60 *p<0.001***

ANOVA test   ** Correlation is significant at the 0.05 level (2-tailed).*
 ** Correlation is significant at the 0.01 level (2-tailed).

Table (1): Showed that there was no statistically significant difference between all groups regarding demographic and medical data. The table revealed that the mean ages in years among compression, leg position and (compression and leg position) were (46.20 ± 7.40, 44.30 ± 6.50and 51.20 ±4.60 respectively) and majority were females and office workers. The mean BMI of all groups were (31.12±1.21, 25.23±5.17 and 22.53±13.41 respectively). Around two fifth of them had more than 5 years of past knee pain and large percentage of them had no chronic disease and their affected leg were the right leg.

Figure (1): Presented that a statistically significance difference was found between all groups after 28 days of operation regarding the knee swelling. The compression and leg position group had a significant improvement post operatively than the other groups (P. 0.002*).

Figure (2): Indicated that a statistically significance difference was found between all groups after 28 days of operation regarding the knee range of motion (degrees). The table also showed that a significant increase in the degree of range of motion after 28 days post arthroplasty among compression therapy & leg position group comparing the other two groups (P. 0.021*).

Figure (3): Showed that there was no statistically significance difference between all studied groups after 28 days of operation regarding the mean pain scores. There was a decrease in the mean analogue pain scores after 28 days post operatively between compression therapy & leg position group comparing the other two groups.

Table (3): Represented that there was statistically significance correlation between all groups after 28 days of operation regarding the BMI and their ages.

Discussion:
The main finding of this feasibility study found no statistically significant differences in the basic data of patient's demographic & medical data between the three studied groups. This is important to ensure comparability of the two groups and indicate successful randomization of the groups. This is confirmed by **Boonchoo et al., (2019)** who ensured the good randomization and reliability of the data.

The age less than two thirds of patients in each group ranged between 40 ≤ 55 years old. This finding contradicts the findings of **Brophy et al., (2014),** who claimed that the majority of patients with TKA in their study; patients mean age and standard deviation were 59 ± 10 years old. However, this is not match with **Hansen et al., (2019)** who mentioned that TKA was among the significantly younger age than older patients.

The researcher opinion of view, surgery is a marker for knee injury in the younger patients, not the cause of early knee osteoarthritis. Meniscal and ligament tears are the injuries which should being treated with surgery, as underlying clinical problem. Selecting to treat these injuries with surgery is not an option, because TKA among those injured victim well be necessarily due to the long-term change development of osteoarthritis among them.

In terms of gender the current study data, revealed that more than half of the three groups were female this findings disagrees with **Miozzari et al., (2021)** who stated that, men are more likely than women to have had previous knee surgery prior to TKA, and the effect of previous knee surgery is more profound on men, as those patients undergo TKA at an average age of more than ten years old younger than men without previous knee surgery. The interval from knee surgery to TKA is longer for men than for women.

In this line, **Keenan et al., (2019)** stated that the risk of early conversion to total arthroplasty is significantly increased in females and those older than 47 years old. These risk factors should be considered pre-operatively when planning intervention for isolated medial compartment osteoarthritis

The implications are concerning given the increasing prevalence of knee surgery, especially ligament reconstruction in young and female patients. Although the rising prevalence of obesity and the advancing age of the population have led to a greater demand for knee arthroplasty, the increasing volume of ligament and meniscal surgery may also be a factor increasing the demand for knee arthroplasty in a younger population **(Rice et al., 2019)**.

It is also predicted that obese patients have a 2.8 greater chance of using walking aid after therapy than non-obese patients **(Bjork & Ehmann, 2019).** The researcher opinion that an increased BMI leads to excessive pressure placed on the newly replaced knee and could influence the rate and success of the rehabilitation.

Regarding the patient's occupation in the current study, the highest percentage of the studied patients in each group were office workers. This is match with **Jenny et al., (2021)** who reported that the highest percentage of patients undergoing total arthroplasty were nonsporting. In addition, **Kort et al., (2020)** concluded that TKA may be a valuable tool to help some patients to continue working but may not affect patients who are already unemployed.

Medical data of the studied total knee arthroplasty patients in the present study founded that the BMI mean and SD of all groups were (31.12±1.21, 25.23±5.17 and 22.53±13.41 respectively). In this

respect, **Hayes et al., (2020)** concluded that overweight individuals with a BMI greater than 27 kg/m2 are more likely to show symptoms of knee osteoarthritis. This relationship is due to the excess amount of weight that the joint is sustaining. This is not agreed with **Boyce et al., (2019)** who mentioned that an increasing number of TKA performed on obese patients.

The present study found that the most affected leg was the right one, with non- significant difference between the three groups. This is match with **Burgess et al., (2021)** who found that the most affected knee of osteoarthritis was the right leg. However, this is not match with **Röhner et al., (2019)** who found no difference between both legs in relation to indication of TKA.

In the current study, around two fifth of patients in each group had more than 5 years of past knee pain and majority had no chronic disease. This match with **Rice et al., (2019)** who confirmed that osteoarthritis is a chronic disease associated with chronic pain. In this respect, **Doiron-Cadrin et al., (2020)** found that their studied patients with osteoarthritis, usual outbreak to preceding between 6 and 12 weeks.

The present study found that there was a statistically significance difference between all studied groups after 28 days of operation regarding the knee swelling. The compression and leg position group had a significant improvement post operatively than other groups.

In this respect, **Hendrickx et al., (2020)** documented that postoperative knee swelling is a common problem due to intra-articular bleeding and inflammation of periarticular tissues.

This is match with **Cook et al., (2019)** who found that use of an inelastic, short-stretch compression bandage following TKA is a safe technique that is acceptable to patients. A larger, multicenter trial is required to determine its effect postoperatively.

Liu et al., (2020) added that, the use of inelastic bandages is preferred in arthroplasty as they have a low, tolerable resting pressure but a more effective activation of the deep venous system and calf-muscle pump with ambulation compared to their elastic counterparts. Also, **Matthews et al., (2019)** reported that auxiliary position (using seats, the legs are located as specified by the manufacturer.) appears to be more efficacious when compared to the straight leg raising, regarding the prevention of cardiovascular adverse effects associated with deflation.

From the researcher's opinion of view, applying two methods in the treatment plan together help in increase may duplicate the benefits and decrease the swelling postoperatively and help in strength, mobility, and fitness.

Other study done by **Osman, (2020)** negated any significant effect of leg rising on the postoperatively swelling. **Christensen et al., (2021)** in their study also, found no effect of wearing of elastic compression post arthroplasty swelling.

Concerned to post arthroplasty pain, the present study found that there was no statistically significance difference between all studied groups after 28 days of operation regarding the mean pain scores. Although, there was a great decrease in the mean analogue pain scores after 28 days post operatively between compression therapy & leg position group comparing to the other two groups.

These findings are consistent with **Reynaud et al., (2020),** who found that raising leg can be safely given to patients undergoing arthroplasty surgery because no adverse effects were observed.

Furthermore, the findings of this study agreed with **Crawford et al., (2020),** who noted that the most recent guideline on the use of compression in preventing post-arthroplasty discomfort and demonstrated that this aspect should be utilized in conjunction with raising leg procedures.

In the existing study, compression therapy together with leg position, which most likely helped with post-operative range of motion after 28 days post arthroplasty among this group comparing to other groups with a statistically significance difference between all studied groups.

Swelling must be reduced for the knee to increase its ROM, and this could be accomplished through the use of anti-inflammatory drugs, ice, and elevation. Once the swelling is controlled, the physical therapist can fully concentrate of gaining range of motion exercise (**Warren et al., 2019).**

Hsu et al., study in **(2019)** had demonstrated that a range of 67˚-93˚ is needed in order to have a normal gait, climb and descend stairs, and rise from a chair. Knees without injury typically have a range of motion from 0-140˚. Patients who have undergone total knee replacement are not required to regain all of the motion; however, they are encouraged to gain a range of 0-120˚.

In some cases, range of motion is difficult to regain after the total knee replacement, and surgeons may consider manipulation if 90˚ of flexion is not achieved within 10-14 days of the surgery (**Bodendorfer et al., 2017).** Closed manipulation is best if used in the first three months following the operation (**Ding et al., 2020).** From the researcher's point of view, manipulation is very painful and is considered to be a last resort if the patient is not achieving the desired results by the rehabilitation performed by the physical therapist.

Similarly, **Weißenberger et al., (2020)** reported that, the methods which including leg position & elastic compression increase the development of a significant improvement, decrease in tissue pressure, ensuring the expansion of the affected joint and enhancing easily and safely range of motion.

Likewise, the study findings are consistent with those of **Li et al., (2021),** who discovered that, compression therapy was able to improve and increase the angle of the affected knee after arthroplasty and lead to beneficial effect on gait and patient daily activity.

Additionally, **Sidhu et al., (2019)** who appraised that, the efficiency of compression with elevated leg practice for the avoidance of post arthroplasty complications, by all accounts, are more powerful. Post arthroplasty swelling and pain diminished by utilizing compression therapy and leg position with low-level resistance training was given for minimizing swelling to decrease pain and improved leg function.

From the researcher's point of view, improving post arthroplasty knee function in the compression therapy and leg position group, because they benefit from the great and combined effect of applying them than the single effect of the use one of them.

However, the findings of this study may differ from those of **Kamath et al., (2019)**, who found no statistically significant differences in the risk of developing a knee condition or the type of complication after arthroplasty between participants receiving compression application and other measures compared to those receiving physiotherapy as leg position. There was no evidence that was effective in reducing complications after arthroplasty.

Regarding the correlation between BMI and age mean of all patients' groups. This study result revealed that there was a statistically significant difference between all the evaluated patients after 28 days of the operation.

In the instance, **Keeney et al., (2019)** found that for total knee arthroplasty, there was consistent evidence that surgical procedures in morbidly obese patients associated with numerous concerns, including patient age, and having lower absolute physical function improvement, in addition to 30-day mortality and surgical site infection. Several institutions have implemented formal or informal cutoff thresholds for performing TKA in patients with high BMI, usually at the morbid obesity level.

Finally, it was concluded that application of both flow compression therapy and leg position together among arthroplasty patients resulting in significantly improved postoperative outcome decreasing swelling and enhancing range of motion and decreasing pain but with no significant difference.

Conclusion

Based on the findings of the current study, compression therapy and leg position were associated with a lower incidence of post-operative swelling, with a highly statistically significant difference between the three groups in terms of post-operative swelling but not regarding pain. In addition, there was statistically significant relation between BMI and age mean of the patients in the three groups.

Recommendation:

Based on the findings of the study, researchers highly advise that compression therapy and leg position should be used combined rather than alone for each one as an intervention to improve patient outcome (swelling and discomfort) among arthroplasty patients. Prepare Arabic colored picture source for patients undergoing TKA containing all of steps of performing compression therapy and leg position in the correct manner and put in the orthopedic outpatient clinic and inpatient department. Reapplication of the study on a larger sample selected from different geographical areas of Egypt is recommended to generalize the study results, taking in to consideration the present limitations.

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