

## Efficacy of Buerger Allen Exercise on Local Circulation and Wound Healing of Children's Lower Extremities Post Orthopedic Surgeries

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### Abstract

**Background:** Lower extremities orthopedic surgeries carry a major risk for devastating complications as incision complication, venous thromboembolism; prohibition of these complications is the foremost nursing goal. Buerger-Allen exercise is capable of improving child's lower extremity tissue perfusion thus boosting wound healing. **The aim** of this study was to evaluate the efficacy of Buerger Allen exercise on local circulation and wound healing of children's lower extremities post orthopedic surgeries. **Research design:** a quasi-experimental research design was conducted. **Sampling:** purposive sampling of 60 children who recently had foot and ankle orthopedic surgery at Pediatric Surgical Orthopedic Department at Tanta Universal Teaching Hospital was carefully selected and enrolled in the current study. **Tools:** three tools were employed to assemble the requisite data including; Structured interview questionnaire schedule, Tissue perfusion assessment sheet, and Surgical wound healing assessment sheet. **Results:** the present study revealed that Buerger Allen Exercise was efficient in improving local skin temperature, wound edges and adjacent skin color, supporting granulation tissue formation and epithelialization, enhancing the ankle brachial index score, reducing capillary refill time, peripheral tissue edema, wound size and depth, wound exudate, and necrotic tissue type and amount. **Conclusion:** Buerger Allen exercise was beneficial in improving lower extremity circulation, tissue perfusion, and wound healing in children who had foot and ankle orthopedic surgery. **Recommendation:** Specific training program pertaining to Buerger Allen exercise in the postoperative phase in pediatric orthopedic should be designated and presented in special training sessions to all orthopedic nurses.

**Key words:** Buerger Allen exercise, Local circulation, Wound healing, Children's Lower extremities, Orthopedic surgeries.

### Introduction

Pediatric orthopedic surgeries are the most conclusive approach of treatment in pediatric orthopedics addressing wide range of conditions and deformities resulting from developmental or genetic disorders, neoplastic disorders, nutritional disorders, infection, neurological conditions, or physical injuries that

necessitate extensive surgical intrusions to recover musculoskeletal alignment, functional abilities, control pain, and advance the child's quality of life.<sup>(1, 2)</sup> Lower extremities orthopedic surgeries are one of the most commonly performed surgical procedures in the pediatric populace; among these are foot and ankle surgeries which require a skillful,

experienced management since children and adolescents have unique foot and ankle anatomy; particularly the existence of growth plates, along with specific needs that cannot be treated the same ways as those of adults. (3, 4)

Postoperative sequels are typically known, largely anticipated potential outcomes of surgery; however unfavorable outcomes are an inevitable event. Orthopedic surgery of the foot and ankle is no exception, as there is always a risk for ubiquity of complications as surgical site infection, venous thromboembolism, incision complication, non/ mal-union, and reoperation. (5, 6) Thromboembolic disease presents as deep venous thrombosis and/or pulmonary embolism is one of the most prevailing and most lethal of all complications arising in the postoperative orthopedic children. Lower extremity orthopedic surgeries, venous stasis, as well immobilization are significant risk factors. (7)

Improving blood circulation by lower extremity exercise has been considered one of the most effective non-pharmacological managements for children succeeding orthopedic surgery on the lower limb. The calf muscles “the body's second heart”, when exercised, its pump function intensifies which sequentially improve lower limb circulation, walking capacity, wound healing. Buerger’s exercises considered a muscle pump postural treatment modality that is capable of increasing vascularization thereby increase lower extremity tissue perfusion. (7, 8) By optimizing and strengthening the work of small muscles, this exercise serves to raise the demand for oxygen and nutrients in blood vessels, enhance circulation, speed up the healing of foot wounds, clear away

stagnant blood and help establish collateral circulation, also avoiding foot deformities. (9)

The pediatric orthopedic nurses play a vital complementary role in caring for children going through orthopedic surgery on lower extremities as they are accountable for preserving health, safety, and high quality of life for the children and their family. The orthopedic nurse is responsible for continuing the pre-operative care plan, adjusting it to address the child’s postoperative status; focusing on the prevention of compromised peripheral circulation and enhancing local circulation and wound healing post-operatively, through encouraging mobilization and exercises, especially Buerger Allen exercise, as early as possible after lower extremities orthopedic surgeries and as tolerated by the child. (10, 11)

**Significance of the study:** Lower extremities orthopedic surgeries convey a complex scenario for child health with a great risk of thromboembolic disease. (12) The risk of venous thromboembolism after lower extremities orthopedic surgery is ranging from 0.4%: 1.0% despite the usage of thromboprophylaxis, while in the absence of preventive processes, the incidence rate of deep venous thrombosis after surgery is equal to 40-60%, the incidence of pulmonary embolism is 20%, and the fatal pulmonary embolism is 0.1–2%; these ratios indicate a necessity for improved postoperative prophylactic plans for high-risk children. (13) Burger’s Allen exercises are a low-cost, low-risk, conventional treatment which encompass easily performed activities that aid to mitigate the consequences of the surgery by increasing the rate of blood flow, removal of stagnant blood, improving

wound healing and reducing limb cyanosis and swelling subsequent pediatric orthopedic surgery on lower extremities. (14)

There is inadequate evidence correlated with the influence of Buerger Allen exercise on peripheral circulation and wound healing amongst children with lower extremities orthopedic surgeries. So this study is developed to investigate that influence.

#### **Aim of the study**

**The study was conducted to** evaluate the efficacy of Buerger Allen exercise on local circulation and wound healing of children's lower extremities post orthopedic surgeries.

#### **Subjects and Method**

A quasi-experimental research design was used in the existent study. The study was conducted at Pediatric Surgical Orthopedic Department at Tanta Universal Teaching Hospital.

**Sample:** A Purposive sampling of 60 children were carefully chosen from the formerly mentioned setting in the course of the study period. The sample size was calculated with Epi- info software statistical package. The calculation was instituted on type 1 error 0.05 and confidence level 95%. They were alienated into two equivalent groups; 30 children for each group as following:

1. **Study group (I):** Thirty children who applied Buerger Allen exercise.
2. **Control group (II):** Thirty children received routine postoperative care.

#### **Inclusion Criteria for selected children: -**

- Age between (6-18) years old.
- Children from both sexes.
- Children who recently had foot and ankle orthopedic surgery.

#### **Exclusion criteria: -**

- Children with other physical disabilities.
- Children with chronic diseases such as type I diabetic mellitus and heart diseases.
- Children with no palpable extremity pulse.

#### **Three tools were used in the current study as follow:**

##### **Tool I: Structured Questionnaire Schedule:**

It was established by the researcher after appraising the pertinent literature in order to assemble socio- demographic as well as clinical data of children. (15, 16) It was consisted of two parts:

**Part (1) Socio-demographic characteristics of studied children:** It was concerned with data as: age, gender, child's birth order, residence, and educational level of the child.

**Part (2) Clinical data of the children:** It was concerned with data as: diagnosis, child weight, height, date of admission, length of hospital stay, date & type of orthopedic surgery, and whether the child is complaining from any other medical conditions.

##### **Tool II: Tissue perfusion assessment sheet:**

It was compromised of two parts to evaluate tissues perfusion of lower extremities.

**Part 1: biomarkers of local tissue perfusion assessment (17, 18):** was developed by the researcher after reviewing the pertinent literature; including data such as:

- Capillary refill time (CRT): A CRT of 1 to 2 seconds is considered normal, while CRT of longer than 2 seconds indicates poor perfusion.
- Local skin temperature: cold skin temperature is a characteristic indicator of peripheral vasoconstriction. It was assessed through palpation.

- Oxygen saturation measured using pulse oximeter at big toe of an afflicted lower limb compared to that from a remote site.

### Part 2: Ankle Brachial Index (ABI).

The ABI (Originally developed by Winsor in 1950) <sup>(19,20)</sup> is a standard simple, non-invasive method used to assess tissues perfusion of lower extremities; it was adopted and calculated by the researcher via a manual sphygmomanometer to measure each ankle systolic pressure (Posterior tibial or Dorsalis Pedis) and each arm brachial systolic pressure, then dividing the greater of the two systolic pressures for each ankle was by the highest brachial systolic pressures of the two arms to acquire the right and left ABI.

**Scoring system:** The score was calculated and interpreted as follow:

<b>Above 0.90</b>	Normal tissue perfusion
<b>0.71 – 0.90</b>	Mildly impaired tissue perfusion
<b>0.41 – 0.70</b>	Moderately impaired tissue perfusion
<b>0.0 – 0.40</b>	Severely impaired tissue perfusion.

**Tool III: Surgical wound healing assessment sheet:** It compromises of two parts:

#### Part 1: surgical wound assessment <sup>(21)</sup>:

In 2020, South West Regional Wound Care Program (SWRWCP) stakeholders and health care partners collaboratively developed this tool; it was then adjusted and filled out by the researcher. It included such items that were assessed once a week for a period of 2 weeks and at any time a change was distinguished as: the location of the incision, closure method, the presence of an acute inflammatory response, healing ridge, also the presence; number; location; and output amount of surgical drains, cleanliness of the surgical

wound and frequency of wound care, signs of internal or external hemorrhage, and the incidence of any signs of wound infection.

### Part 2: Bates-Jensen Wound Assessment Tool (BWAT):

It was originally advanced in 1990 by Barbara Bates-Jensen <sup>(22)</sup> and adopted by the researcher in the current study, which involve 13 items objective events envisioned to assess wound status and track healing as size, depth, edges, undermining, necrotic tissue type and amount, exudate type and amount, skin color surrounding the wound, peripheral tissue edema, peripheral tissue induration, granulation tissue, and epithelialization. The wound was assessed pre and 14 days post application of Buerger Allen exercise/ routine care and every time a change is noted.

#### Scoring system was classified as follow:

1:13 indicate wound regeneration.

>13:60 indicate wound degeneration.

#### Method

#### Administrative, legal and ethical consideration:

- An official permission was attained from the Faculty of Nursing, Tanta University, before the study was conducted. An authorized letter from the dean of Faculty of Nursing then was conveyed to the appropriate authorities in the designated area of the study; acquiescence to conduct the study was attained from the directors of the Pediatric Surgical Orthopedic Department at Tanta Universal Teaching Hospital.
- Ethical and legal approval from the research ethics committee of the Faculty of Nursing, Tanta University [code 5-11-21] and Faculty of Medicine, Tanta University [code 35014/ 11/ 21] were attained.

- Nature of the study didn't induce any harm or pain to the entire sample.
- Oral consents were gained from all children or their parents for contribution in the study after being informed of the aim of the study and their right to withdraw at any time. Study children and their parents were guaranteed that any information obtained would be kept confidential and utilized only for the study purpose.

#### Methods of data collection

- The study's tools were examined for content validity by a panel of 7 experts in pediatrics and pediatric nursing; who appraised the tools for clarity, relevance, understanding, comprehensiveness, and easiness for administration. Modifications were made in accordance. The face validity was calculated based on experts' opinion; it was 97.2%.
- A pilot study was carried out on 10% of the sample (6 children) that were randomly selected and then excluded from the study sample to judge the tools for clarity, applicability, feasibility, in addition to ascertain hindrances and problems that may be encountered during data collection process and the indispensable modifications were done.
- The study tools were tested by the pilot subjects. The test of reliability (Cronbach's alpha) for **Tool II, part 1**; biomarkers of local tissue perfusion assessment was reliable at (0.895) and **part 2**; Ankle Brachial Index (ABI) scale test was reliable at (0.912). Also **Tool II, part 1**; surgical wound assessment was reliable at (0.88) and part 2; Bates-Jensen Wound Assessment tool was reliable at (0.898).

**Phases of the study:** The researcher was present at morning shift in all available days in the aforementioned setting. The field of work encompassed the following

phases that were carried out by the researcher for all study subjects:

**1. Assessment Phase:** After the installation of a brief idea about the aim of the study, each child was interviewed separately to assemble the necessary data using the tool I, part (1, 2). The assessment was done on day one before intervention using tool II and tool III.

**2. Implementation phase:** Children in the control group received routine postoperative care including monitoring vital signs, managing pain, assessing the surgical site, routine wound care, and ambulation. While children in the study group applied Buerger Allen exercise besides routine postoperative care.

Using a colored booklet, Buerger Allen exercises were coached to the children in study group or their support person (mother or care giver), which was followed then by return demonstration from the child.

Children were inculcated to perform the exercise for at least **three sessions a day** in consistence with the child tolerance; every session be composed of three stages. The exercise could be executed with assistance two days after surgery.

- **In the first stage, Elevation**, the child lie flat with legs raised about 45° to 90° angle directly above the heart level until blanching is discerned (about 2: 3 minutes).
- Then in **the second stage, Dependency**, the child sited on margin of the bed, making sure that their legs are further lowered than the rest of the body and that there is no compression alongside the posterior aspect of the knees to fill the vessels waiting for redness to emerge (for almost 5: 10 minutes). Then, if it is

tolerated by the child; he/she exercised the feet by internal and external rotation, plantar flexion, and dorsiflexion.

- To end with, **the third stage** in which the child lied horizontally flat for around 5: 10 minutes with a warm blanket covered their feet before repeating the exercise.

**3. Evaluation phase:** Following completing fourteen days performing Buerger's Allen exercises, both study and control groups conducted an immediate post-test using Tool II, part 1, 2 to assess tissue perfusion of lower extremities, and surgical wound healing was assessed through using Tool III, part 2 (Bates-Jensen Wound Assessment Tool), while Tool III, part 1 was reevaluated 7- and 14-days post interventions. The result of the study group then was compared with those of the control group that only received routine post-operative care; to determine the exercises' efficiency.

**Duration of data collection:**

Data was collected within 6 months; covering the period from the first of March to the end of August 2022.

**Statistical analysis:**

The collected data were organized, tabulated, fed to the computer and statistically analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range, mean, standard deviation. Chi-square test ( $\chi^2$ ) was used for categorical variables, to compare between different groups. For analyzing the significance between the different stages, McNemar and Marginal Homogeneity Test were used. Mann Whitney test was used for

abnormally distributed quantitative variables, to compare between two studied groups. For abnormally distributed quantitative variables, to compare between two periods, Wilcoxon signed ranks test was used. The correlation between variables was estimated using Pearson and Spearman's correlation coefficient  $r$ . Significance of the attained results was arbitrated at the 5% level.

**Results**

**Table (1): Shows the percentage distribution of the studied children in relation to socio-demographic characteristics.**

this table reveals that more than one third (36.7%), and (33.3%) of the studied children aged between 6 and less than 9 years old, with mean age ( $11.45 \pm 4.09$ , and  $11.01 \pm 3.54$ ) in study and control group respectively. it was observed that more than half of the studied children (60.0%), (56.7%) in study and control group correspondingly were male. It was observed that more than one third of children in the study group (40%) were the first-born child in the family, while more than one third of children in the control group (40%) were the 2<sup>nd</sup> born child. More than half (53.3%), and (56.7%) of the studied children in study and control group respectively were living in urban areas. For children educational level, it constitutes that, (46.7%) of children in both study and control group were in primary education level.

**Figure (1): illustrate the indications of orthopedic surgery in studied children,** it was observed that more than half (56.7%), and (53.3%) of children in study and control group respectively were operated due to congenital anomalies.

**Figure (2): Portrays the location of the surgical incision in studied children,** it

was observed that 40% and 36.67 % of children in study and control group respectively had a surgical incision located at Forefoot.

**Table (2): Clear up the mean scores of studied children regarding Ankle Brachial Index.** Regarding to the ABI index of right foot, there were highly statistically significant differences among children of study group where ( $P_1 = 0.001$ ). As well there were highly statistically significant differences among children of control group where ( $P_1 = 0.003$ ). **Apropos to the ABI index of left foot**, there were highly statistically significant differences among children of study group where ( $P_1 = <0.001$ ). As well a highly statistically significant differences were found among children of control group where ( $P_1 = 0.001$ ). When comparing the two groups in 14 days after interventions, statistically significant differences was observed regarding the improvement of ABI score in right feet and in left feet where ( $p = 0.015$ , and  $0.029$ ) correspondingly.

**Figure (3): Spectacles capillary refill time (CRT) of studied children.** It was observed that more than half of studied children in the study group (56.7%) had CRT more than 2 seconds before application of Buerger Allen exercise, then 14 days after the exercise performance a significant improvement was observed with the majority of the studied children (90%) had CRT less than 2 seconds. **On** comparing the two groups based on the mean scores plotted, there were highly statistical difference among studied children of the study and control groups regarding the total score of wound status on wound status continuum where  $U = 162.0$ ,  $P_3 = <0.001$ .

**the other hand, concerning to the control group;** it was observed that more than half of studied children (60.0%) had CRT more than 2 seconds before routine care, then more than half of studied children (60.0%) had been improved and had CRT less than 2 seconds 14 days after the care.

**Figure (4): Displays local skin temperature of studied children.** Concerning the study group; a significant improvement was observed with more than half of studied children' affected limb (53.3%) were cold before application of Buerger Allen exercise, then 14 days after the exercise enactment the majority of the studied children' affected limb (93.33%) were warm. **On the other hand, concerning to the control group;** no significance difference was observed with near to half of studied children' affected limb (46.7%) were cold before routine care, then 14 days after the care more than half of studied children' affected limb (63.3%) were warm.

**Table (3): Depicts percentage distribution of studied groups in relation to wound status continuum.** It was noticed that there was highly statistical difference ( $P_1 = <0.001$ ) among studied children in study group before and 14 days after application of Buerger Allen exercise, whereas there is no statistical difference ( $P_1 = 0.125$ ) among studied children in control group before and 14 days after receiving routine postoperative care. **When Table (4): Presents the correlation between total score plotted on wound status continuum and Ankle Brachial Index (ABI) score.** Taking into consideration that a higher ABI score implies normal tissue perfusion and lower total wound score indicating improved healing process and wound regeneration,

and vice versa; it was observed that there was a negative significant correlation between ABI score and the total score of wound among studied children in study group before application of Buerger Allen exercise where ( $p= 0.034$ , and  $0.025$ ) in right and left feet respectively, which has been changed into a negative highly significant correlation after application of exercise where ( $p= 0.002$ ,  $0.007$ ) in right and left feet correspondingly. On the other hand, in the control group there was a negative significant correlation between ABI score and the total wound score before receiving routine postoperative care where ( $p= 0.041$ ) in right foot, which turned into a negative highly significant correlations after receiving routine postoperative care where ( $p= <0.009$ ) in right foot, while there was a negative significant correlation in left foot where ( $p= 0.030$ ) after receiving routine postoperative care.



**Table (1): Percentage distribution of studied children in relation to socio-demographic characteristics.**

Socio-demographic characteristic of children	Study group (n = 30)		Control group (n = 30)	
	No.	%	No.	%
<b>Age in years</b>				
6 – <9	11	36.7	10	33.3
9 – <12	6	20.0	5	16.7
12 – <15	4	13.3	9	30.0
15 – 18	9	30.0	6	20.0
<b>Mean ± SD.</b>	<b>11.45 ± 4.09</b>		<b>11.01 ± 3.54</b>	
<b>Sex</b>				
Male	18	60.0	17	56.7
Female	12	40.0	13	43.3
<b>Child's Birth order</b>				
First	12	40.0	9	30.0
Second	7	23.3	12	40.0
Third	8	26.7	7	23.3
Fourth	3	10.0	2	6.7
<b>Residence</b>				
Rural	14	46.7	13	43.3
Urban	16	53.3	17	56.7
<b>Educational level</b>				
Read and write	5	16.6	4	13.3
Primary education	14	46.7	14	46.7
Preparatory	3	10.0	6	20.0
Secondary education	8	26.7	6	20.0

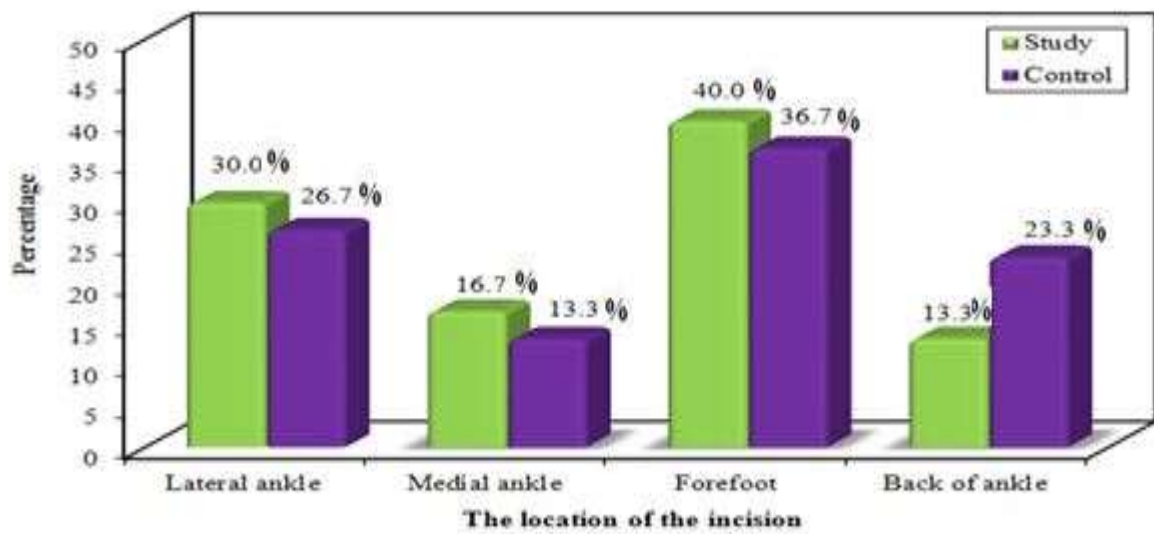
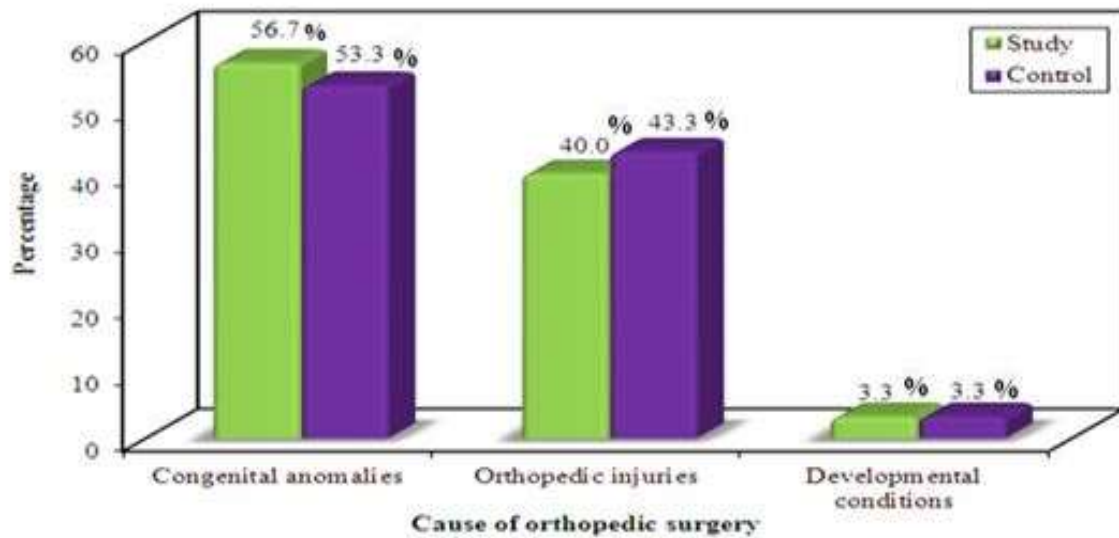
**Figure (1): The indications of orthopedic surgery in studied children****Figure (2): The location of the incision in studied children**

Table (2): Mean scores of studied children regarding Ankle Brachial Index

Ankle Brachial Index (ABI)	Study group		Control group		U P <sub>2</sub>	U P <sub>3</sub>
	Before	After 14 days	Before	After 14 days		
<b>Right</b>	(n = 20)	(n = 20)	(n = 18)	(n = 18)	<b>160.50</b> <b>0.573</b>	<b>97.50</b> <b>0.015*</b>
Range.	0.60 – 0.89	0.81 – 0.97	0.55 – 0.88	0.39 – 0.96		
Mean ± SD.	0.75 ± 0.10	0.91 ± 0.05	0.73 ± 0.11	0.81 ± 0.15		
<b>Z, p<sub>1</sub></b>	<b>3.211, 0.001**</b>		<b>2.943, 0.003**</b>			
<b>Left</b>	(n = 19)	(n = 19)	(n = 21)	(n = 21)	<b>177.50</b> <b>0.555</b>	<b>119.5</b> <b>0.029*</b>
Range.	0.55 – 0.88	0.64 – 0.97	0.59 – 0.86	0.56 – 0.96		
Mean ± SD.	0.75 ± 0.10	0.90 ± 0.09	0.73 ± 0.09	0.84 ± 0.12		
<b>Z, p<sub>1</sub></b>	<b>3.828, &lt;0.001**</b>		<b>3.444, 0.001**</b>			

U: Mann Whitney test

Z: Wilcoxon signed ranks test

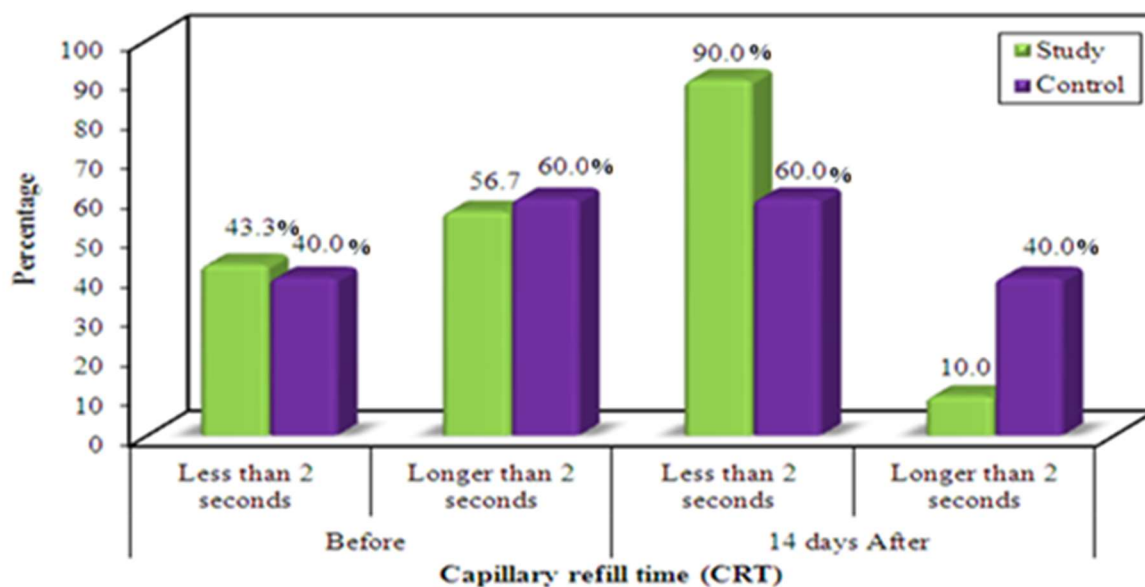
P<sub>1</sub>: p value for comparing between **before and after 14 days** in each groupP<sub>2</sub>: p value for comparing between the two studied groups **in Before**P<sub>3</sub>: p value for comparing between the two studied groups **in after 14 days**\*: Statistically significant at  $p \leq 0.05$ \*\*: highly statistically significant at  $p \leq 0.01$ 

Figure (3): Capillary refill time (CRT) of studied children

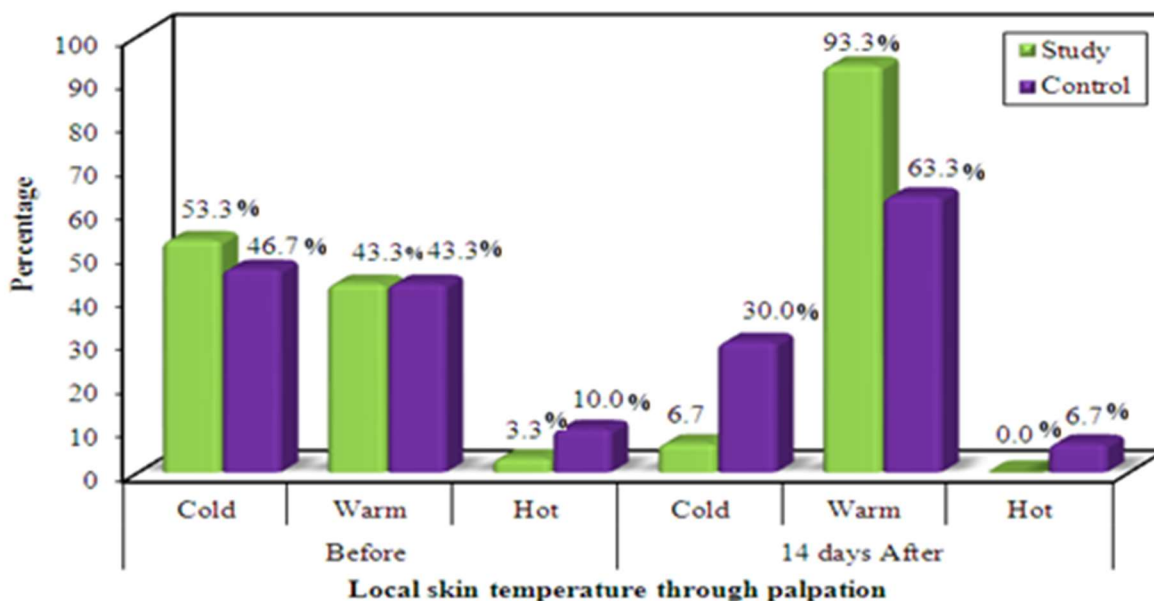


Figure (4): Local skin temperature of studied children through palpation

Table (3):Percentage distribution of studied groups on the subject of wound status continuum

Total score Wound status continuum	Study group (n = 30)				Control group (n = 30)				Test of Sig, p <sub>2</sub>	Test of Sig, p <sub>3</sub>
	Before		After		Before		After			
	No.	%	No.	%	No.	%	No.	%		
Wound regeneration (1:13)	0	0.0	13	43.3	0	0.0	4	13.3	χ <sup>2</sup> , p 6.648, 0.010*	
Wound degeneration (>13:60)	30	100.0	17	56.	30	100.0	26	86.7		
McN p <sub>1</sub>	<0.001*				0.125					
Range.	24.0 – 41.0		13.0 – 25.0		24.0– 42.0		13.0 – 39.0		U, P <sub>2</sub> ±408.0, 0.533	U, p <sub>3</sub> 162.0, <0.001**
Mean ± SD.	33.13 ± 4.76		15.23 ± 2.91		32.53 ± 4.78		21.67 ± 6.66			
Z, p <sub>1</sub>	4.786, <0.001**				4.639, <0.001**					

SD: Standard deviation

U: Mann Whitney test

Z: Wilcoxon signed ranks test

χ<sup>2</sup>: Chi square test

McN: McNemar test

P<sub>1</sub>: p value for comparing between before and after 14 days in each group

P<sub>2</sub>: p value for comparing between the two studied groups in Before

P<sub>3</sub>: p value for comparing between the two studied groups in after 14 days

\*: Statistically significant at p ≤ 0.05

\*\* : highly statistically significant at p ≤ 0.01

**Table (4): Correlation between total score plotted on wound status continuum and Ankle Brachial Index (ABI) score**

Ankle Brachial Index (ABI)		Total score Wound status continuum			
		Study group (n = 30)		Control group (n = 30)	
		Before	After	Before	After
Right	r <sub>s</sub>	-0.475*	-0.644**	-0.485*	-0.599**
	P	0.034*	0.002**	0.041*	0.009**
Left	r <sub>s</sub>	-0.512*	-0.598**	-0.395	-0.473*
	P	0.025*	0.007**	0.076	0.030*

r<sub>s</sub>: Spearman coefficient

\*: Statistically significant at  $p \leq 0.05$

\*\* : highly statistically significant at  $p \leq 0.01$

### Discussion

Children with foot and ankle musculoskeletal pathology habitually need extensive surgical interferences in order to repair deformities and boost lower extremities function. Such extensive surgery reinforces significant tissue damage and can potentially trigger formation of deep vein thrombosis (DVT), one of the most common complications following lower extremities orthopedic surgery. Deep vein thrombosis not only decelerates children recovery but also impacts prognosis, and increasing risk of devastating complications. <sup>(23, 24)</sup> For that reason the enhancement of peripheral circulation is fundamental. So; this study was focused on assessment of the efficacy of Buerger Allen exercise on local circulation and wound healing of children's lower extremities post orthopedic surgeries at Pediatric Surgical Orthopedic Department at Tanta Universal Teaching Hospital.

The result of existing study revealed that more than one third of the studied children aged between 6 and less than 9

years old. The mean age of the studied children was ( $11.45 \pm 4.09$ , and  $11.01 \pm 3.54$ ) in study and control group respectively. The current study was in agreement with **Do-Hyeong Kim (2018)** <sup>(23)</sup> who found that the mean age of studied children submitted to major orthopedic surgery of the lower extremities were ( $10.0 \pm 1.7$  and  $9.3 \pm 2.5$ ) in study and control group consistently. It was noticed that, more than half of the studied children in study and control group respectively were male; this may be explained by the fact that male sex are more predisposed to some of the most common foot congenital deformities as club foot, flat feet, ingrown toenails, tarsal coalition, besides, male children and adolescent are more active than female counterparts, which make them more inclined to exhibit foot and ankle orthopedic injuries. This finding was in agreement with **Shore (2020)** <sup>(25)</sup> who reported that, more than half of the studied children were male.

More than one third of children in study and control group had a surgical incision located at Forefoot. This finding was in harmony with **Hu (2020)** <sup>(26)</sup> who

conducting a study to compare the patient-reported outcomes for major pathologies of the forefoot, mid-foot, hind foot, and Achilles indicating that more than one third of studied subjects had a major pathology affecting the forefoot.

Foot and ankle orthopedic disorder carry a great risk for impaired peripheral circulation and development of thromboembolic disease; this risk is augmented by the distance of surgical site from the heart as well as immobilization after surgery. (254) Buerger Allen exercise helped to evade this problem as it meant to boost lower extremities blood flow, permitting the capillary refill time, local skin temperature, oxygen saturation at affected limb and tissue perfusion (measured using Ankle Brachial Index) to improve.

**On the subject tissue perfusion markers**, the finding of the present study revealed that, Buerger Allen exercise significantly improve CRT, local skin temperature, Oxygen saturation at big toe of an affected lower limb. This result was reinforced by **El Sayed (2021)** <sup>(27)</sup> who indicated that there was statistically significant improvement among studied subjects in lower extremities perfusion indicators comprising (skin temperature, capillary refill time, peripheral pulses, pain, edema and skin color) 15 days after implementing Buerger Allen exercise in right & left leg. This finding is likewise congruent with **Thakur and Sharma (2019)** <sup>(28)</sup> who illuminate that Buerger Allen Exercise was effective in improving lower extremities perfusion amongst studied subjects. This finding is also supported by **Chen (2017)** and **Lin (2018)** <sup>(29, 30)</sup> who institute that, Buerger's

exercise significantly improved peripheral oxy-hemoglobin (HbO<sub>2</sub>) concentration, required for proper wound healing, at post-exercise stages.

**On the topic of Ankle Brachial Index score** pre, and 14 days after Buerger Allen exercise enactment, the extant study results disclosed that there were no statistical significant differences between both groups before interventions for both right and left limbs, but there were highly statistically significant improvements of ABI mean scores in both limbs of studied children in study group before and 14 days after exercise, there were also statistically significant improvements of ABI MS between study and control groups after two weeks of exercise implementation. This improvement may be ascribed to a consistent exercise regimen for a long enough time, which helps to stimulate the development of collateral circulation in the lower extremities and enhance peripheral blood flow.

These preceding results were consistent with the studies done by **Prakash (2022)** and **Miskin (2022)** <sup>(31, 32)</sup> who revealed in their studies that there were highly statistical significant difference between the mean ABI scores of both legs post Buerger Allen exercise than before exercise. Moreover the study result was in harmony with **Hafid (2021)** and **Radhika et al., (2020)** <sup>(33, 34)</sup> who revealed that there is a significant advance in the mean score of ABI among the studied subjects after applying Buerger Allen exercise in the right and left limb. Similarly, the result of the current study was harmonious with the study established by **Rushdy (2021)** <sup>(35)</sup> which exhibited that six weeks after

implementing Buerger Allen Exercise, there was a highly statistically significant improvement in ABI between the study group compared to control group.

Current study finding demonstrates that Buerger Allen exercise considerably improves wound characteristics; this could be explained by the effect of postural exercises (Buerger Allen exercise), which improve local collateral circulation by altering posture and muscular activity, which in turn increases oxygen delivery to the bloodstream and distributes nutrients to cells and tissues, thereby boosting wound healing. on the topic of surgical wound size calculated by multiplying wound length by width as well as necrotic tissue (amount and type), there was statistical significant difference between the two studied groups 14 days after the interventions where  $P= 0.010$ ,  $0.021$  respectively. Furthermore, there was highly statistically significant difference between the mean scores for wound depth, edges, granulation and epithelialization among the two studied groups 14 days after the interventions where  $P= <0.001$  equally. These finding was supported by **Vijayarathi (2014)** <sup>(36)</sup> who reported that, there was highly statistically significant difference between experiment and Control group concerning wound size, depth, edges, necrotic tissue (amount and type), wound exudate (amount and type), granulation and epithelialization on 15<sup>th</sup> day after application of Buerger Allen exercise  $P= 0.001$  similarly.

When comparing the two studied groups regarding the total score of wound status on wound status continuum, the result of present study revealed that there was highly statistical difference among

studied children of the study and control groups. The result of existing study concurred with those of **Mordi and Dhudum (2020)** <sup>(37)</sup>, who discovered a significant difference in the wound healing average scores post-test among studied groups with  $p$  value  $0.000$ . At the same time this study was agreement with **Ramaprabhu (2018)** <sup>(38)</sup> who illustrates that after implementing Buerger-allen exercise, the pretest mean wound scale score was lower than posttest mean wound scale score indicating that Buerger Allen exercise was more effective than traditional approaches.

There was a negative significant correlation between ABI score and the total score of wound among studied children in study group before application of Buerger Allen exercise where ( $p= 0.034$ , and  $0.025$ ) in right and left feet respectively, which has been changed into a negative highly significant correlation after application of exercise where ( $p= 0.002$ ,  $0.007$ ) in right and left feet correspondingly. This can be explained as a higher ABI value implies normal tissue perfusion; tissue and wound bed perfusion adequacy has been identified to be the most critical indicator of wound healing following foot and ankle surgeries by means of it increasing nutrients supply to tissues and cellular oxygenation which plays a fundamental role in the expansion of new capillaries, synthesis of collagen, and infection prevention and control thereby boosting wound regeneration leading to lower total wound score.

This finding was in accordance with **Zahran (2018)** <sup>(15)</sup> who reported that, there was a significant negative correlation between patient's ABI and

ulcer surface area before and after performing Buerger Allen exercises where p values were found to be ( $p=0.027$ ) in Pre-test and ( $p =0.035$ ) in immediate posttest.

### **Conclusion and Recommendations**

In conclusion, the results of this study demonstrate that Buerger Allen exercise was beneficial in improving local circulation, tissue perfusion, and lower extremity wound healing in children who had foot and ankle orthopedic surgery. Significant study findings indicate that implementing the Buerger Allen Exercise is an effectual technique for reducing capillary refill time, helping to improve local skin temperature, enhancing the ankle brachial index (ABI) score, and reducing wound size and depth, necrotic tissue type and amount, wound exudate, and peripheral tissue edema, in addition to improving wound edges and surrounding skin color, supporting granulation tissue formation, and epithelialization. There was a negative significant correlation between ABI score and the total score of wound plotted on wound status continuum among studied children.

### **Recommendations:**

Based on the findings of the present study, the following recommendations are suggested:

#### **For nursing practice:**

1. Specific training program pertaining to Buerger Allen exercise in the postoperative phase in pediatric orthopedic should be designated and presented in special training sessions to all orthopedic nurses.
2. Encourage health care professionals, especially nurses to integrate Buerger Allen exercise in the treatment protocols

of children post lower extremities orthopedic surgery.

#### **For nursing education:**

1. In-service educational program on post-operative complication of lower extremities orthopedic surgery as well postoperative care should be directed to nurses at pediatric orthopedic department to advance their practice and reduce the incidence of postoperative complication.
2. Manual log book about post-operative care of children suffered a foot and ankle orthopedic surgery, including the exercise program following surgery especially Buerger Allen exercise should be accessible to nurses at pediatric orthopedic department as a reference.

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