Available online at Journalgurus

https://www.jhspract.com https://www.journalgurus.com

Original Article

Assessment of Thoracodorsal Artery Perforators of Adults: A Comparative Study Between Hand-Held Doppler and Colour Doppler Ultrasound

[1]Joshua D. Choji, [2*]Christopher Y. Karago, [3]Anthony E. Gabkwet, [4]Simon J. Yiltok

1.Department of Surgery, Jos University Teaching Hospital, Jos, Nigeria. 2. Department of Plastic Surgery, Prince Mishari bin Saud Hospital, Baljurashi, Bahah Region, Kingdom of Saudi Arabia. (*Formerly of the Jos University Teaching Hospital, Jos). 3. Department of Radiology, College of Health Sciences, University of Jos/Jos University Teaching Hospital, Jos, Nigeria. 4. Department of Surgery, College of Health Sciences, University of Jos/Jos University Teaching Hospital, Jos Nigeria.

ABSTRACT

Background: The thoracodorsal artery perforator flap has emerged as a versatile workhorse flap for reconstruction. The popular assessment tools for the assessment of perforators are the Hand-Held Doppler (HHD) and colour Doppler ultrasound (CDU). HHD has gained an important place as a diagnostic tool in the field of perforator flaps because of its ease of use, low cost and availability. This study aimed at comparing the HHD and CDU in the assessment of the number of thoracodorsal artery perforators. **Methodology**: This was a comparative cross-sectional study; two scanning modalities were used to assess the thoracodorsal artery perforators in the same group of patients that were selected by a consecutive sampling method. The Plastic Surgeon assessed the perforators using the HHD, with a re-evaluation of the same locations by a Consultant Radiologist using the CDU. The assessment was on both sides for those who met the inclusion criteria. Thus, the total number of lateral thoracic areas assessed was 140. The data generated was analysed using the statistical package for the Social Sciences (SPSS) version 20, and statistical significance was determined using a dependent sample t-test and p-value of <0.05 was considered significant. **Results**: Seventy subjects were assessed, 58 (82.9%) males and 12 (17.1%) females. The male-to-female ratio was 4.8: 1. The age range was 18 - 65 years with a mean of 31.77 years ± 11.72 years. Overall (right and left lateral thoracic sides), CDU (M = 0.94, SD = 0.48) identified more perforators than HHD (M = 0.85, SD = 0.51) and was statistically significant, t (419) = 3.667, p = 0.000. **Conclusion:** This Study demonstrated that the CDU identified more perforators when compared with the HHD and was statistically significant. The CDU should be used pre-op or made available in the theatre, which is cumbersome.

Keywords: Thoracodorsal artery perforators, Hand-held Doppler, Colour Doppler ultrasound, comparison.

INTRODUCTION

A perforator (a perforating vessel) is a vessel that has its origin in one of the axial vessels of the body of the body, besides interstitial connective tissue and fat, before reaching the subcutaneous fat and that passes through certain structural elements layer.[1] A perforator flap is a flap consisting of skin and/or subcutaneous fat supplied by perforator(s).[1] Thoracodorsal artery perforator (TAP) flap has emerged as a workhorse flap for reconstruction of defects and is versatile in its indications as it provides cutaneous cover that can be used anywhere in the body. It can be used as a pedicled flap for lateral neck, pharyngeal tubing, breast, axilla, and arm[2] and as a free flap used in

Corresponding Author

Dr Joshua D. Choji,
Department of Surgery,
Jos University Teaching Hospital, Jos, Nigeria.
Email: joshuachoji55@gmail.com

cutaneous resurfacing of any part of the body from head and neck to the feet.[2, 3]

Preoperative localization of perforators avoids prolonged surgery time, and intraoperative mishaps, which increases the surgeon's confidence.[4] Selective angiography can provide an accurate picture of source vessels and perforators but is invasive and results in radiation exposure. Magnetic resonance imaging has no risk of radiation but requires great sophistication and expense. Hand-Held Doppler (HHD) and colour Doppler Ultrasound (CDU) are non-invasive and more pragmatic modalities for evaluating cutaneous circulation.[5] HHD sonography is a useful tool that can provide the necessary preoperative information about the vascular anatomy of perforators. This method is simple, highly portable, and easy to interpret, and its probe can be used intraoperatively to finalize the planning of a surgical procedure. However, a HHD ultrasound probe cannot distinguish between perforating vessels and main axial vessels if they are located superficially, which can then create a false positive localisation of the perforators.[4,6,7]

Blondeel et al.[7] in a study compared preoperative marking and intraoperative anatomical findings of TAP flaps and found a high number of false positive and false negative signals. The sensitivity and positive predictive value (PPV) were unacceptably low, of the 11 TAP flaps in 9 patients, only 6 were investigated and the use of HHD was discontinued. However, Jaffar et al.[3] in India reliably performed the preoperative mapping of thoracodorsal artery perforators (TAPs) using HHD in 26 patients who underwent head and neck reconstruction with free TAP flaps from 2015 to 2018. Intraoperatively, perforators were found in all the patients. Yang et al.[8] used the HHD to identify TAPs before surgery in 67 TAP flaps (eight were free flaps while 59 were pedicled flaps).

All the cases had perforators that were pulsatile and larger than 0.5 mm intraoperatively and all flaps survived. Also, computed tomographic findings were compared with HHD and intraoperative findings by Mun et al.[9] in 25 patients who had TAP flap reconstruction. Preoperative mapping was done with multidetector-row computed tomographic angiography and one to four perforators were marked on the three-dimensional computed tomographic image for each patient.

In the operating room, the mapped data was transferred to the patients' skin, and perforators were searched for with a sterile HHD probe. During the surgery, all perforators marked were confirmed, and three additional perforators that had not been identified on the computed tomographic images were observed. All the perforators that had been marked on the patient's skin using the computed tomographic data produced an audible sound on Doppler examination. By implication, careful assessment of perforators with HHD will likely be reliable.

Although CDU proposes more precise information on the number and locations of cutaneous perforators than HHD, it is limited by cost, cumbersome apparatus, and time-consuming scanning, and it requires skilled scanning personnel.[5, 7, 10, 11] The most popular examination methods for the assessment of perforator flaps are the HHD and CDU[10] which have been evaluated in multiple studies on other perforators.[5,10,12,13,14] However, there is a dearth of direct comparisons between HHD and CDU which involved small numbers of patients[10] especially for the TAPs. In view of efforts in the use of perforator flaps[15] and free microvascular flaps in our environment[, 17], there is a need to evaluate the two modalities. HHD has gained an important place as a diagnostic tool in the field of perforator flaps because of its ease of use, low cost and availability[7] which makes it still valuable in low- and medium-income countries like ours. The aim of this study was to compare the HHD with CDU in the assessment of thoracodorsal artery perforators.

MATERIALS AND METHODS

Study Design

This was a comparative cross-sectional study that assessed the number of thoracodorsal artery perforators using HHD and CDU.

Study Location

This study was carried out in the Jos University Teaching Hospital (JUTH) located in Lamingo, Jos-North Local Government Area of Plateau State, Nigeria.

Sample Size

The minimum sample size was calculated using the G*Power version 3.1.9.2 statistical power analysis program.[18]

The following input parameters were used: The applicable test for the study is a t-test and the appropriate one selected for this study was the difference between two dependent means (Matched pairs)
Tails = two
Effect size = 0.5
Alpha level = 0.05
β error = 20% (0.20): the minimum acceptable probability for type 2 error
Power (1– β) = 80% (0.80)
Minimum sample size was calculated as = 34 persons. The minimum sample size was then multiplied by two; 34 x 2 = 68 and rounded up to

70 persons. This was done to increase the precision of estimation for the results obtained.[19]

Inclusion Criteria

- Adult outpatients, between 18 to 65 years, attending clinics in JUTH
- Patients with intact and healthy lateral thoracic area
- Patients that have not had surgery previously in the lateral thoracic area
- Patients with no documented regional or systemic vascular anomalies

Exclusion Criteria

Patients with major trauma to the lateral thoracic area

Presence of infection or ulcer at/or around the lateral thoracic area

Ethical Clearance

Ethical approval was obtained from the ethics committee of Jos University Teaching Hospital, with reference number JUTH/DCS/IREC/127/XXX/2123, where the study was conducted, and international best practices were ensured.

Informed Consent

Informed consent was sought from all individuals that met the inclusion criteria, based on standard best practice.

MATERIALS AND METHODS

The materials used included: a consent form, questionnaire, weighing scale, skin marker, tape rule, Huntleigh hand-held Doppler model MD2, and colour Doppler ultrasound GE model Logiq V5.

The participants were selected by consecutive sampling method until a sample number of 70 was reached. Necessary and appropriate informed consent was obtained from adult persons who presented to the Jos University Teaching Hospital outpatient clinic. Their lateral thoracic areas were then examined for obvious scars, deformities or ulcers. Those that met the inclusion criteria were recruited and filled the questionnaires, their weight and height were taken and recorded. They were then taken to the ultrasound room and made to lie down on a couch in lateral decubitus position, with the ipsilateral arm at ninety degrees (90º) abduction and the elbow flexed. The lateral border of the latissimus dorsi (LD) muscle was palpated and marked on the overlying skin with a temporary marker. The first point (A); 8 cm distal to posterior axillary fold and 2 cm medial to the lateral border of the LD muscle was marked; then the second point (B) was 2-4 cm below A; and the third point (C) 2-4 cm below B. (Figure 1)

A Plastic Surgeon then used the HHD to assess for perforators at these points.

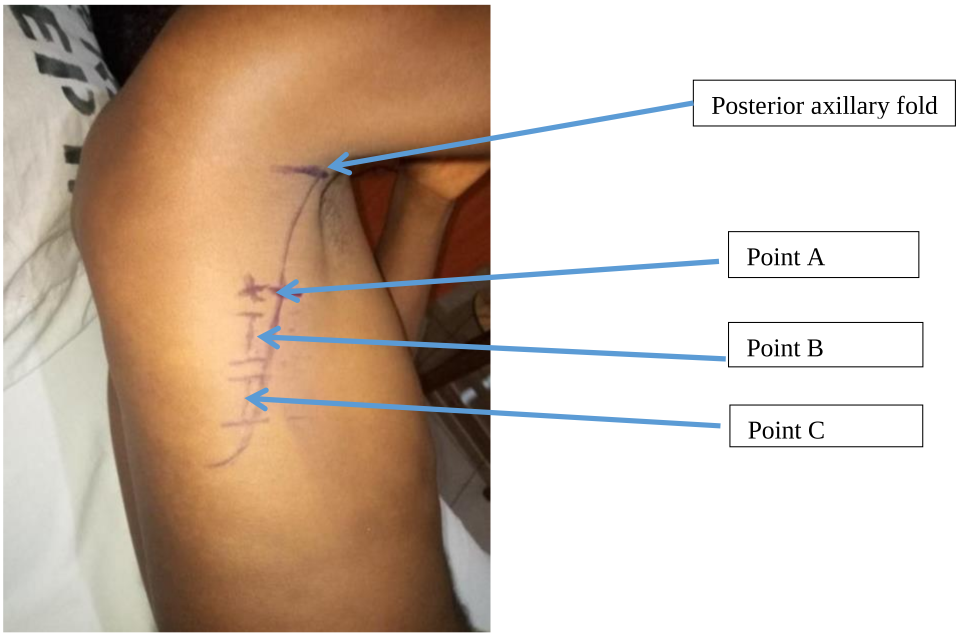

Figure 1: Marked perforator points A, B and C: Point A was 8 cm distal to posterior axillary fold and 2 cm medial to LD border, Point B was 2 to 4 cm below A, and point C was 2 to 4 cm below C.

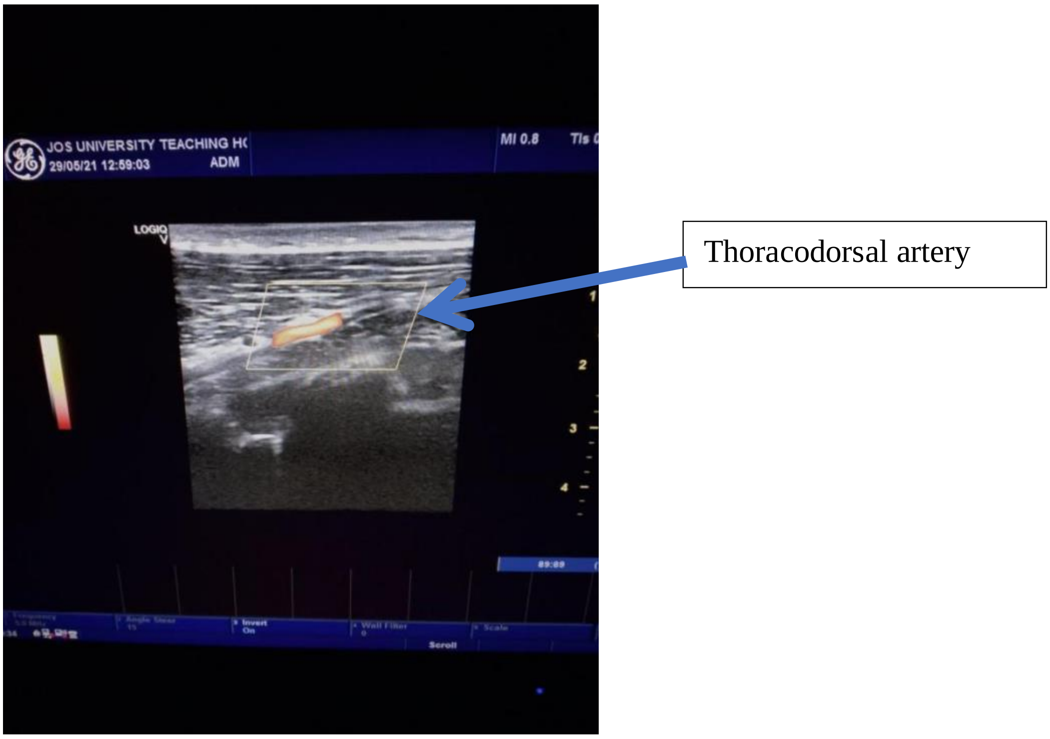

Figure 2: Thoracodorsal artery demonstrated on CDU

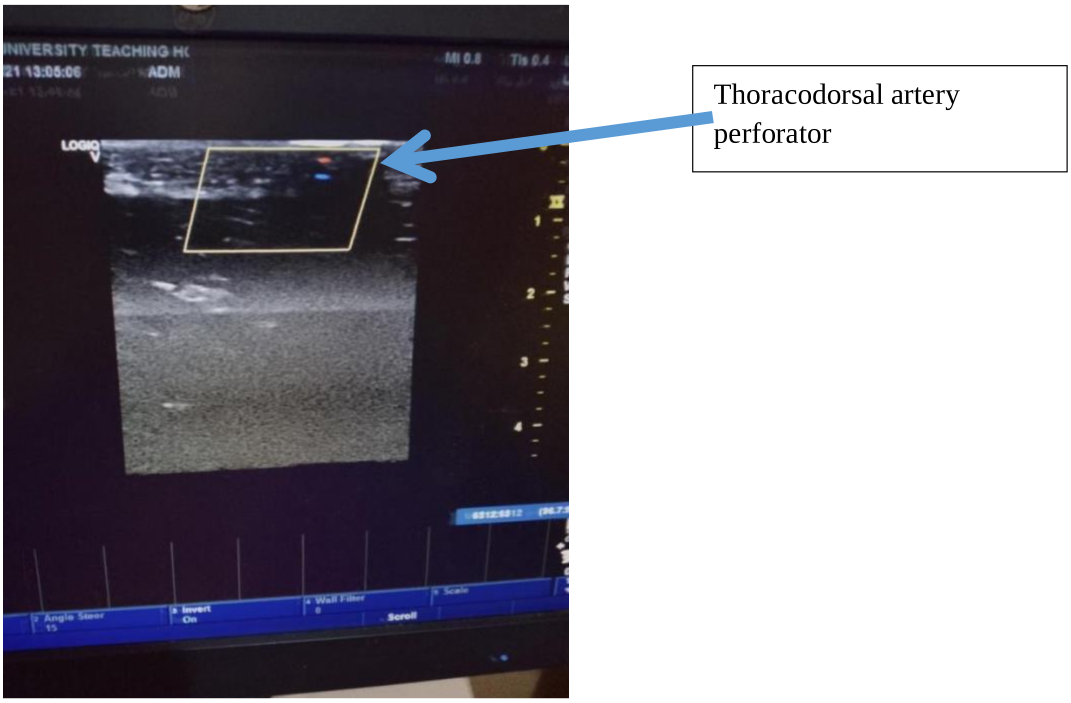

Figure 3: Thoracodorsal artery perforator demonstrated

Signals within 1 cm radius centred on the points were considered positive for the points. When a signal was positive it was recorded as one perforator present. If no signal it was considered negative and recorded as zero. The procedure was then repeated by a Radiologist using the CDU at the same points as above. (Figures 3 and 4) The procedure was also carried out on the contralateral sides as they met the inclusion criteria. Thus, a total of 140 lateral thoracic areas were assessed.

Data Analysis

After attaining the calculated sample size, the data was analysed using the computer package, Statistical Package for the Social Sciences (SPSS) version 20. The data was presented in tables and statistical significance was determined using a dependent (paired) sample t-test. All tests with p value less than 0.05 were considered significant.

RESULTS

A total of 70 patients were recruited for the study. The demographic distribution is shown in Table 1: there were 58 males (82.9%) and 12 females (17.1%) with a male-to-female ratio of 4.8:1. The age range was 18 to 65 years with a mean of 31.77 years ± 11.72 years.

Table 1: Age, Sex, and BMI distribution of the study

Variable	Frequency	Percentage
Age group		
$\leq$20	10	14.3
21-30	31	44.3
31-40	13	18.6
41-50	10	14.3
>50	6	8.6
Total	70	100.0
Sex		
Male	58	82.9
Female	12	17.1
Total	70	100.0
BMI		
Underweight	3	4.3
Normal	48	68.6
Overweight	12	17.1
Obese	7	10.0
Total	70	100.0

Overall (right and left sides), CDU (M = 0.94, SD = 0.48) identified more perforators than HHD (M = 0.85, SD = 0.51) and was statistically significant, t (419) = 3.667, p = 0.000.

On the left lateral thoracic area, CDU picked signals more than the HHD and was statistically significant, CDU (M = 0.97, SD = 0.49) and HHD (M = 0.85, SD = 0.50), t(209) = 3.274, p = 0.001. On the right side, CDU identified more perforators than the HHD but there was no significant difference between the two modalities, CDU (M = 0.91, SD = 0.47) and HHD (M = 0.85, SD = 0.52), t (209) = 1.868, p =0.063. (Table 2)

DISCUSSION

The HHD has gained an important place as a diagnostic tool in the field of perforator flaps because of its ease of use and availability.[12] Though CDU of the donor area can give much more information,[7] the HHD is being used with success as reported by Ademola et al.[15] in Ibadan and Yang et al.[8] in China. The two modalities have been evaluated in multiple studies, but there is a dearth of direct comparison especially for the TAPs. This study compared the HHD and CDU in the assessment of TAPs.

The study showed that CDU (M = 0.94, SD = 0.48) identified more perforators than HHD (M = 0.85, SD = 0.51), t (419) = 3.667, p = 0.000. This supports the findings by Nanno et al.[13] in Japan who reported that CDU identified approximately 1.5 times the number of cutaneous perforators detected by HHD in the assessment of second dorsal metacarpal artery perforators. Lethaus et al.[10] in Germany also showed a statistically significant difference, p = 0.030, in the number of perforators detected between CDU and HHD in the planning of ALT flaps. The CDU identified 93 perforators and missed two, while the HHD identified 86 and missed nine.

The findings from our study are similar to findings by Stekelenburg et al.[12] in the Netherlands who examined perforators at the elbow and umbilical regions using the Duplex sonography as a standard for comparison and found that 45% of the signals assessed by the HHD were not confirmed by duplex and therefore assessed as false positives. Of these false positives, 32% were axial vessels and 45% were intramuscular vessels. From the foregoing, our findings and those of other aforementioned studies demonstrated the superiority of the CDU over HHD. This could be due to the reason that HHD examination often misidentifies or misses arteries, particularly in evaluating small vessels, and perforators running obliquely from muscle to the skin.[13] Another reason may be due to the ability of the CDU to identify the perforators as they arise from the axial vessels and can be followed to the skin. It may also be due to the differences in anatomic regions with the vessels being deeper or more superficial.

Our study revealed the superiority of CDU (M = 0.94, SD = 0.48) over HHD (M = 0.85, SD = 0.51),

t (419) = 3.667 which was statistically significant, P = 0.000. On the contrary, Yang et al.[8] in China used the HHD to identify thoracodorsal artery perforators (TAPs) before surgery in 67 TAP flaps. all the patients. The reason for the discordance in results could be due to the difference in study design. Our study involved only sonography and is operator-dependent while the others involved surgery which entails direct visualisation of the

Table 2: Comparison of the assessment of thoracodorsal artery perforators at points A, B, and C using Hand-held Doppler and colour Doppler ultrasound

Point	HHD (Mean±SD)	CDU (Mean±SD)	t	df	p
Right					
A	0.81 ± 0.39	0.84±0.37	1.425	69	0.159
B	1.03 ± 0.61	1.13±0.45	1.355	69	0.180
C	0.70 ± 0.49	0.76±0.49	0.893	69	0.375
Total	0.85 ± 0.52	0.91 ± 0.47	1.868	209	0.063
Left					
A	0.90±0.30	1.00±0.24	2.769	69	0.007
B	0.99±0.63	1.16±0.58	2.254	69	0.027
C	0.66±0.48	0.74±0.50	1.229	69	0.223
Total	0.85±0.50	0.97±0.49	3.274	209	0.001
Overall right and left	0.85±0.51	0.94±0.48	3.667	419	0.000

SD = Standard deviation, t = t-test (dependent), df = degree of freedom (n – 1), p = p-value

The correlation between TAPs for HHD and CDU at points A, B and C on the right side were all significant: At point A; r = 0.904, p = 0.000, at point B; r = 0.356, p = 0.003, and point C; r = 0.411, p = 0.000. Also, on the left side, correlations were all significant: at point A; r = 0.398, p = 0.001, at point B; r = 0.445, p = 0.000 and point C; r = 0.292, p = 0.014. (Table 3)

Table 3: Correlation between thoracodorsal artery perforators for Hand-held Doppler and colour Doppler ultrasound at points A, B and C

Point	r	p
Right		
A	0.904	0.000
B	0.356	0.003
C	0.411	0.000
Left		
A	0.398	0.001
B	0.445	0.000
C	0.292	0.014

r = correlation coefficient, p = p-value

All the cases had perforators that were pulsatile and larger than 0.5 mm intraoperatively. Again, Jaffar et al.[3] in India reliably performed the preoperative mapping of TAPs using HHD in 26 patients who underwent head and neck reconstruction with free TAP flaps from 2015 to 2018. Intraoperatively, perforators were found in perforators; therefore, this may be responsible for the difference. Also, computed tomographic findings were compared with HHD by Mun et al.[9] in South Korea in 25 patients who had TAP flap reconstruction. Preoperative mapping was done with multidetector-row computed tomographic angiography. In the operating room, perforators were searched for with a sterile HHD probe.

All perforators marked by HHD were confirmed, and three additional perforators that had not been identified on the computed tomographic images were observed. All the perforators that had been marked on the patient's skin using the computed tomographic data produced an audible sound on Doppler examination. The possibility of identifying all perforators with HHD after mapping with a computed tomography scan may be due to bias from the earlier markings with computed tomography. This may explain the reason HHD was able to identify all perforators without missing some as in our study.

In clinical practice, our outcome implies that, when HHD findings are inconclusive, the CDU could be considered as an additional tool to verify the mapping of perforators preoperatively.

This will give the surgeon more confidence, enhance his speed and reduce operating time.

Limitations of the Study

1. 1Ultrasound examination is operator-dependent, and the researcher is expected to have some knowledge and familiarity with skin perforators.

2. The assessment was not done independently (CDU was performed immediately after the HHD assessment at the same locations), thus, it may be subject to expectation bias.

CONCLUSION

This study has shown that the CDU identified more perforators when compared with the HHD. The CDU demonstrated superiority over HHD in the assessment of the number of TAPs of adults and was statistically significant.

Recommendations

1. Future studies should compare the HHD and CDU with intraoperative findings to validate their reliability in the identification of TAPs.
2. Flaps including TAPs may be designed using CDU for preoperative planning, while the HHD could be used intraoperatively to confirm perforator locations before raising the flaps.

Financial Support and Sponsorship

The authors did not receive any financial support for the study

Conflict of interest

The authors declare that there is no conflict of interest. This study was submitted to the Faculty of Surgery of the West African College of Surgeons (April 2021) in part fulfilment for the award of fellowship.

Authors' Contribution

1. Joshua D. Choji: participated in the concept, design, definition of intellectual content, clinical studies, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, and manuscript review.
2. Karago Y. Christopher: Took part in concept, design, definition of intellectual content, clinical studies, manuscript preparation, manuscript editing and review.
3. Anthony E. Gabkwet: Took part in the concept, design, clinical studies, definition of intellectual content, data acquisition, manuscript editing, and manuscript review.
4. Simon J. Yiltok: participated in the concept, design, definition of intellectual content, clinical studies, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, and manuscript review.

REFERENCE

1. Blondeel PN, Van Landuyt KHI, Monstrey SJM, Hamdi M, Matton GE, Allen RJ et al. The "Gent" Consensus on perforator flap terminology: Preliminary definitions. Plast Reconstr Surg 2003; 112(5): 1378-83.
2. Jain L, Kumta SM, Purohit SK, Raut R. Thoracodorsal artery perforator flap: Indeed a versatile flap. Indian J Plast Surg 2015; 48: 153-8.
3. Jaffar S, Jaiswal D, Shankhdhar VK, Bindu A, Mathews S, Mantri M, Kumar V, Yadav PS. Free Thoracodorsal Artery Perforator Flap for Head and Neck Reconstruction: An Indian Experience. Indian Journal of Plastic Surgery. 2023 Nov 3;56(06):499-506.
4. Karkhanis S, Bali N, Alo K, Tzortzis S, Athanasiadou M, Azad S. An analysis of hand-held Doppler knowledge and accuracy in lower limb arterial perforator assessment. J Plast Reconstr Aesthet Surg 2011; 64(4): e107-108. doi: 10.1016/j.bjps.2010.12.013
5. Hallock G G. Doppler sonography and colour duplex imaging for planning a perforator flap. Clin Plast Surg 2003; 30: 347-357.
6. Mun G, Jeon BJ. An efficient method to increase specificity of acoustic Doppler sonography for planning a perforator flap: Perforator compression test. Plast Reconstr Surg 2006; 118(1): 296-297. doi :10.1097/01.prs.0000222221.88939.58
7. Blondeel PN, Beyens G, Verhaeghe R, Van Landuyt K, Tonnard P, Monstrey S J et al. Doppler flowmetry in the planning of perforator flaps. Br J Plast Surg 1998; 51(3): 202-209.
8. Yang L, Wang X, Bentz ML, Fang B, Xiong X, Li X et al. Clinical application of the thoracodorsal artery perforator flaps. J Plast Reconstr Aesthet Surg 2013; 66: 193-200
9. Mun G, Kim H, Cha M, Kim W. Impact of perforator mapping using Multidetector-row Computed Tomographic Angiography on free thoracodorsal artery perforator flap transfer. Plast Reconstr Surg 2008; 122: 1079-1088
10. Lethaus B, Loberg C, Kloss-Brandstatter A, Bartella AK, Steiner T, Modabber A et al. Colour duplex ultrasonography versus hand-held Doppler to plan anterior lateral thigh flaps. Microsurgery 2017; 37(5): 388-393.
11. Cheng H, Lin F, Chang SC. Diagnostic efficacy of colour Doppler ultrasonography in preoperative assessment of anterolateral thigh flap cutaneous perforators: An evidenced-based review. Plast Reconstr Surg 2013; 131(3): 471e-473e. doi:10.1097/prs.0b013e31827c733e
12. Stekelenburg CM, Sonneveld PMDG, Bouman M, Van der Wal MBA, Knol DL, de Vet HCW et al. The hand-held Doppler device for the detection of perforators in reconstructive surgery: What you hear

is not always what you get. Burns 2014; 40(8): 1702-1706.
13. Nanno M, Kodera N, Tomori Y, Hagiwara Y, Takai S. Colour Doppler ultrasound assessment for identifying perforator arteries of the second dorsal metacarpal flap. J Orthop Surg 2017; 25(1): 1-5.
14. Khan UD, Miller JG. Reliability of Hand-held Doppler in planning local perforator-based flaps for extremities. Aesthetic Plast Surg 2007; 31: 521-525.
15. Ademola SA, Michael AI, Oladeji FJ, Mbaya KM, Oyewole O. Propeller flap for complex distal leg reconstruction: A versatile alternative when reverse sural artery flap is not feasible. J Surg Tech Case Rep 2015; 7: 23-27.
16. Orkar KS, Yiltok SJ, Karago CY, Akintayo AJ, Sankey BJ: The use of free composite anterolateral thigh flap with vascularised fascia lata for reconstruction of Achilles tendon and soft tissue loss. Nigerian J Plast Surg 2016; 12:28-41.
17. Mofikoya BO, Ugburo AO, Enweluzo GO. Early outcomes of reconstructing complex distal leg defects in Lagos, Nigeria. J Clin Sci 2016; 13: 2-5.
18. Faul F, Erdfelder E, Lang A, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioural, and biomedical sciences. Behav Res Methods 2007; 39: 175-191.
19. Kamangar F, Islami F. Sample size calculation for epidemiologic studies: principles and methods. Arch Iran Med 2013; 16 (5): 295-300.