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ASSOCIATION BETWEEN AV FISTULAS AND HANDGRIP STRENGTH

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Abstract

Introduction: Arteriovenous fistula (AVF) placement is essential for hemodialysis in chronic kidney disease (CKD) patients but may impair handgrip strength (HGS), affecting physical function and quality of life.

Objective: To evaluate the association between AVF placement and HGS in CKD patients, comparing measurements before and three months post-procedure.

Materials and Method: This quasi-experimental study at Ali Fatima Hospital, Bhobatian Chowk, Raiwind Road, Lahore, Pakistan from December, 2023 to May, 2024 enrolled 90 CKD patients aged 20–60 years. HGS was measured using a manual dynamometer before and three months after AVF placement. Patients with upper extremity malformations or other exclusion criteria were excluded. Data were analyzed using SPSS, with paired t-tests ($p \leq 0.05$).

Results: Mean HGS decreased significantly from 21.00 ± 7.35 kg to 19.22 ± 7.92 kg post-AVF ($p < 0.001$). Most AVFs were brachiocephalic (80%), with 64.44% male patients.

Conclusion: AVF placement significantly reduces HGS, necessitating exercise interventions to mitigate functional decline.

Keywords: *Handgrip Strength, Arteriovenous Fistula, Chronic Kidney Disease, Hemodialysis*

INTRODUCTION

The development of an arteriovenous fistula (AVF) is essential for a CKD patient for hemodialysis since it creates a reliable vascular access site for the efficient removal of waste products. However, assumptions that change in blood flow distribution due to the creation of an arteriovenous fistula, as well as potential medical complications such as steal syndrome, might affect upper limb dexterity, especially HGS. Handgrip strength is a confirmatory sign of muscle function, nutrient reserve, and quality of life index that is progressively incorporated and valued within assessing outcomes of hemodialysis patients. There is a symbiotic relationship between AVF placement and HGS as the procedure may be beneficial by improving muscle blood supply through increased blood flow but harmful in the sense that it may cause muscle fatigue, neuropathy, or reduced limb use due to patient's concern regarding possible damage to the fistula. It is crucial to understand this interaction in order to tailor patient management and functioning interventions and functional gains in CKD.

Chronic kidney disease is prevalent in millions of individuals across the world, and a considerable number of ESRD patients require dialysis. In the United States of America, it was estimated that more than 468000 patients depend on hemodialysis, with about 20% of them using AVFs for treatment (1). The AVF is usually developed in the upper limb, with an artery linked to a vein established for it to grow strong and accommodate recurrent venepuncture. AVFs are considered superior to grafts or catheters in terms of longevity and complication rates, but not without some issues at all. Different reports suggest that 28-53% of AVFs do not mature appropriately, and the common reasons include small vessel size, delayed referral, or the presence of atherosclerotic disease (2). There are effective possibilities of maturation that have led to the recognition of preoperative and postoperative exercise programs, such as the handgrip exercises, which proved to increase vessel diameter and blood flow to contribute to fistula functionality (3,4). Nevertheless, the effects of the exercises and the AVF have not been conducted in heterogeneous populations, which is the case with HGS.

Handgrip strength is a widely recognized measure in clinical practice, and it is associated with sarcopenia, frailty, and mortality in hemodialysis patients. Literature shows that HGS is restored to lower levels in CKD individuals as compared to healthy people, which is due to the various systemic consequences of uremia, nutritional deficiency, and muscle atrophy (5). This is because the placement of an AVF may lead to vascular steal, where blood flow is redirected from distal tissues, resulting in ischemia of the hand and muscle weakness (6). Moreover, the constant sessions of dialysis and cholesterol-induced inflammation or neuropathy tend to degrade the status of HGS even more. On the other hand, research exercise interventional such as isometric handgrip training has indicated some benefits in enhancing vascular ob and even helping to also prevent the loss of strength (7, 8). For example, randomized trials have shown that postoperative handgrip exercises can improve AVF maturation by widening the venous lumens, but its immediate impact on HGS remains ambiguous (9). The impact of AVF and HGS is generally influenced by the patient's age, co-morbidities, and the site of the fistula. There are differences in the hemodynamics of proximal fistulas, like brachiocephalic AVFs, compared to distal radiocephalic fistulas, which may influence the HGS (10). Furthermore, it is established that CKD patients have other complications like diabetes and hypertension, bad news for muscle health, as work examining the association between HGS and cardiovascular events indicates (11). Another aspect that affects the quality of life is the extent of HGS, and this is because the condition affects mobility, which in turn leads to depression and the inability to independently perform various activities (12). Although it has been recommended in systematic reviews that preoperative interventions like exercise improve AVF maturation, little is understood about their benefits in preserving or improving HGS (13).

HGS offers clinical significance that is not limited to physical function, as it helps predict future cardiovascular events and all-cause mortality in HD patients. Newer literature has also sought other parameters like myosteatosis on computed tomography, which may add to the application of HGS on IM assessment (14). Moreover, data obtained from other medical fields, like post-trans-radial coronary interventions, revealed that procedure changes could affect HGS and can be compared to AVF (15). Since the number of patients with CKD is increasing throughout the world, it is crucial to improve AVF outcomes and prevent such effects as HGS decrease. The purpose of this paper is to establish the connection between AVF placement and HGS in an effort to raise knowledge around the impact on physical function to improve vascular access as it applies to a patient's quality of life.

Objective: To assess the relation of arteriovenous fistula placement to handgrip strength in patients undergoing CKD, where measurement was taken before and 3 months after the procedure.

MATERIALS AND METHODS

Design: Quasi-experimental study.
Study setting: The study was conducted at Ali Fatima Hospital, Bhobatian Chowk, Raiwind Road, Lahore, Pakistan
Duration: The study spanned from from December, 2023 to May, 2024.
Inclusion Criteria:
Patients who were 20-60 years of age, both male and female, with CKD - 5 / CKD-5D with a GFR of ≤ 15 ml/min/1.73m², who were receiving hemodialysis using an AVF.
Exclusion Criteria
Patients with upper extremity malformations, neurological or muscular disorders, ejection fraction <35%, inflammatory arthritis, prior upper extremity surgery, or peripheral vascular disease were excluded as such conditions will distort HGS.

Methods
A total of 90 patients were included in the study after obtaining written informed consent. Age, gender, medical history, specifically HIV status, were taken on a Proforma prepared for the study. HGS was assessed using a hand grip dynamometer whereby the patients sat on a chair with their back supported, arms and shoulders950 Adduction flexion at 90 degrees, and forearms in a neutral position. Each of the measurements was taken three times, and the average of all the readings obtained in kilogram-force (kg-f) was only recorded. Pre- and post-AVF placement, HGS was measured before and three months after the procedure, irrespective of the hemodialysis. Participants were first informed of the research process to avoid compromising the confidentiality of the study and with an understanding that the activity posed no health risks. For the purpose of ensuring that there is consistency in data collection was conducted by the researcher. The data was analyzed using IBM-SPSS package version 26 with the paired t-test used to compare the HGS before and after the onset of AVF, with a p-value <0.05 considered significant.

RESULTS

In this quasi-experimental cross-sectional study, ninety participants diagnosed with CKD who undergoes arteriovenous fistula (AVF) surgery were recruited to examine the relationship between AVF formation and HGS. The mean age of the participants was established to be 45.41±10.93 years age, ranging from 20 to 60 years. Out of the selected participants, 64.44% were males while 35.56% were female participants, and the male-to-female ratio was 1.8:1. The majority of the AVF accesses were created in the left arm (86; 95.56%), and in four patients (4.44%), the right arm was used. Hemodialysis was started in 73 (81.1%) of patients on average for 2.68 ± 2.93 years (range 0.08 – 12). Coexisting diseases were reported, with 47 patients (52.2%) having diabetes and 84 (93.3%) having hypertension.

Table 1: Demographic and Clinical Characteristics

Variable	Value
Mean Age (years)	45.41 ± 10.93
Male, n (%)	58 (64.44%)
Female, n (%)	32 (35.56%)
Diabetes, n (%)	47 (52.2%)
Hypertension, n (%)	84 (93.3%)
Hemodialysis Initiated, n (%)	73 (81.1%)
Mean Dialysis Duration (years)	2.68 ± 2.93

The AVF anastomosis type was predominantly end-to-side in 84 patients (93.33%), with side-to-side anastomosis in only six patients (6.67%). The most preferred fistula site was brachial-cephalic (72 patients 80%), and the rest were radio-cephalic (11 patients 12.22%) and brachiobasilic (7 patients 7.78%).

Table 2: AVF Characteristics

Variable	n (%)
Left Arm	86 (95.56%)
Right Arm	4 (4.44%)
End-to-Side Anastomosis	84 (93.33%)
Side-to-Side Anastomosis	6 (6.67%)
Brachiocephalic Site	72 (80%)
Radiocephalic Site	11 (12.22%)
Brachiobasilic Site	7 (7.78%)

AVF placement had a negative effect on handgrip strength, which decreased afterward. The mean HGS before receiving AVF was 21.00 ± 7.35 kg (with a range of 10-50 kg), which reduced to a mean of 19.22 ± 7.92 kg (with a range of 8-50 kg) three months after the procedure. The paired t-test was done to analyze the difference, and there was a remarkable lowering in HGS after the formation of the AVF (p-value < 0.001).

Table 3: Handgrip Strength Before and After AVF Placement

Variable	Before AVF	After AVF	p-value
Mean HGS (kg)	21.00 ± 7.35	19.22 ± 7.92	<0.001
Range (kg)	10–50	8–50	-

These findings show that AVF placement greatly reduces the degrees of HGS in the CKD populace including the hemodialysis patients. It may be due to the high proportion of comorbidities and the utilization of brachiocephalic fistulas, which require specific measures to minimize further deterioration of the human condition.

DISCUSSION

The results of this study are proof of the deterioration in the HGS in the time period after the procedure to create the AVF with decreased mean HGS from 21.00±7.35 kg preoperatively to 19.22±7.92 kg, 3 months after the operation (p < 0.001). This finding supports the proposed hypothesis that although AVF creation is necessary for creating hemodialysis access, it denies the upper limb functionality characterized by HGS, which is essential in evaluating the strength of the muscles as well as physical fitness. This study enlarges understanding of the functional effects of the AVF creation and emphasizes the importance of strengthening interventions in CKD patients. These factors may include vascular characteristics, patients' behaviors, the presence of comorbidities, and the role of exercise interventions, though these rates may have declined, hence warranting a discussion within the premise of the existing literature.

Hemodialysis is easily done through an AVF because of its effectiveness and low complication rate compared to grafts and catheters. However, it changes the blood flow of the limb and might produce various complications, such as steal syndrome, where blood is redirected from tissues at the end of the limb, leading to ischemia and weakness (6). In line with the present research, Zeynep Tuna et al. have highlighted that the HGS of both hands of hemodialysis patients is lower than that of the control group, as well as the pinch strength of the patients (6). As pointed out by Rehfuss et al., there is a significant reduction in limb function and grip strength among the patients after AFV, even though there are minimal changes in sensation, therefore implying the importance of hemodynamic changes (7). The marked decrease in HGS measured in the study may be explained by steal syndrome or a decrease in blood supply to the hand without clinical signs of ischemia, as mentioned by Kmentova et al. who demonstrated subtle changes in tissue oxygenation underlying hand dysfunction (9).

Patients may also contribute to the decline of HGS in a number of ways. The patients that have CKD are also reluctant to use the AVF arm since they are afraid of straining the fistula, which results in disuse atrophy and gradual muscle wasting of the limbs. This phenomenon can be explained well by Asif and Javed, who depicted the reduced pinch strength post-hemodialysis in the AVF arm, which indicates that repeated dialysis, as well as limited limb usage, affects muscle health (10). As a result of the study, one realized that the study was largely with males (64.44%) and had a relatively young mean age of about 45.41 years than that revealed in other studies such as Tuna et al., where the age range of the participant was older. This might be due to the fact that the younger patient population might have preserved muscle strength that would otherwise be detrimental by advanced age, sarcopenia, and frailty, which have been identified to be risks for greater reduction in HGS among patients on hemodialysis (11).

Diabetes mellitus (52.2%) and hypertension (93.3%) in the group can significantly affect the HGS reduction in patients with CKD. Yang et al. have established that low HGS in patients under hemodialysis has a relation with cardiovascular and increased death rates and have established that CKD and its complications cover the overall muscular health. Diabetes affects peripheral nerves, which leads to neuropathy and also muscle atrophy, while hypertension can affect the blood vessels and blood flow of the limb after AVF. The absence of distal fistulas in 80% of patients may also affect outcomes since proximal fistulas have been reported to have higher steal syndrome incidence than distal radiocephalic fistulas, which may further augment HGS decline (7). The present study draws attention to the importance of elective selection of the site of arteriovenous fistula creation and recording of its subsequent maturation in order to prevent losses in renal function.

Exercise interventions, especially handgrip training, are an effective approach to increasing the maturation of the arteriovenous fistula and possibly the preservation of HGS. For instance, Manjunath et al.'s study revealed that postoperative handgrip exercises reduce AV access mature positively and also enhance venous diameter, though they do not assess the precise effect of HGS (1). Aragoncillo Sauco et al. noted that preoperative exercise leads to improved vascular caliber, and postoperative initiation of exercise training may enhance AVF to help decrease strength loss (2). Tapia González et al. have also discussed that upper limb isometric exercise has improved the maturation of AVF, where they stressed the importance of structured exercise programs. However, as suggested in Ramanarayanan et al., systematic reviews of preoperative interventions mention that such interventions aid maturation, but as much as the impact of the improvement on functional aspects such as HGS, little research has been executed (4). The lack of exercise interventions in the study indicates that the inclusion of such programs could potentially reverse muscle loss, as indicated by the recorded mean HGS decline.

The impact of HGS reduction is much more far-reaching than just the survival and death rates and pertains to quality of life as well. Macataman et al. have also reported that low HGS in hemodialysis patients leads to less quality of life, restricted mobility, and increased dependency on others for activities (12). Nantakool et al.'s Cochrane review also supports the use of upper limb exercises for the maturation of AVFs but questions the functional significance of this in AVFs (13). Furthermore, new markers, which include CT-based assessment of myosteatosis investigated by Yajima and Arao, could be used alongside HGS to have a more comprehensive description of muscle health (11). Similarly, studies done in non-CKD patients, like Erbay and colleagues' study on the changes in HGS after trans-radial coronary intervention, suggest that procedural vascular changes affect strength in general and underpin the importance of HGS surveillance in patients with AVF (14). Polo-López et al.'s findings on the combined impact of HGS and physical activity on cardiovascular outcomes provide more evidence for HGS's usefulness in predicting the prognosis of patients (15).

Nonetheless, this investigation has some limitations, including a limited number of patients, which is a weakness of this study since patients from a single center were evaluated, and the site of injury confounding could not be analyzed. Continuing the evaluation of these data, future studies should enroll more patients from different centers and investigate the consequences of using AVF for HGS over a more extended period. Presumably, the exercise intervention and more sophisticated imaging approach could define the basis of HGS decline and help determine the rehabilitation approach. Therefore, reducing the dose of AVF placement is an effective way to decrease HGS and improve outcomes in CKD patients because of hemodynamic changes, disuse, and comorbidity factors. This can be adversely impacted by several factors, which can be offset through the integration of exercise programs and patient monitoring.

CONCLUSION

This short-term study supports that HGS is reduced after the creation of the AVF, where the mean HGS decreased from 21.00 ± 7.35 kg to 19.22 ± 7.92 kg the three months after the procedure ($p < 0.001$). This decrease was noted irrespective of the patient's hemodialysis history, and it could be because of changes in vascular patency, steal syndrome, the patient's predisposition to minimize the use of the arm containing the AVF, as well as underlying diabetes and hypertension. These results reveal the effect of AVF on the strength of the upper limb and how it affects everything that an individual engages in daily. The data suggest that combining preoperative and postoperative handgrip exercise programs may help reduce HGS decline and improve AVF maturation. There are limitations in the study that leave room for further improvements, and thus, future multicenter with larger and longitudinal ways and different intervention approaches need to be implemented. Supervising HGS after AVF is important to avoid worsening the patient's condition early and improve the hemodialysis treatment.

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