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ORIGINAL ARTICLE

A Comprehensive Approach to the Management of Supracondylar Humerus Fractures in Children

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ABSTRACT

Background: Supracondylar humeral fractures (SFH) are the most common fractures of the pediatric elbow, with a peak incidence between the ages of four and nine years. The standard treatment includes closed reduction and percutaneous pinning. This study investigates the outcomes of these methods in managing SFH in children.

Patients and Methods: A total of 70 children presenting with supracondylar humeral fractures (Gartland Type III) were enrolled. Patients with neurovascular injuries linked to either open or closed Gartland type-III fractures were excluded. Closed reduction was performed under general anesthesia, with elbow immobilization in extension by two plaster slabs. Data on fracture type, injury pattern, time to treatment, surgical intervention, and outcomes were recorded.

Results: The mean age of patients was 4.92 ± 3.0 years. Of the 70 cases, 56 (80%) were male and 14 (20%) female. Among the 56 children with pulseless hands, 16% had Gartland Type III and 84% had Type IV fractures. The majority of hands (64%) were warm, while 36% were cold. The mean time from injury to presentation was 4.0 ± 2.5 hours. Surgical outcomes included autologous interposition venous grafting in 25%, vascular reconstruction in 60%, and segmental resection with primary anastomosis in 15%. No amputations, fasciotomies, or long-term ischemic complications occurred.

Conclusion: This study confirms that closed reduction and immobilization with two slabs is a safe and effective treatment for managing Gartland Type III supracondylar fractures. Additionally, early vascular exploration can effectively treat both cold and warm pulseless hands.

Keywords: Supracondylar humeral fractures, Management, Children, Close reduction approach

INTRODUCTION

Supracondylar humeral fractures (SFH) are among the most common pediatric elbow injuries, especially in children aged 4-9 years. They represent approximately 60% of all elbow fractures in this age group[1]. These fractures typically occur due to a fall onto an outstretched hand, resulting in a hyperextension injury of the elbow. The majority of these fractures are extension-type, where the distal fragment displaces posteriorly and medially, leading to significant risks for neurovascular compromise, including damage to the brachial artery and nerves, most notably the radial and median nerves[2,3].

Management of SFH has been a subject of considerable debate, particularly in relation to the timing and method of surgical intervention, as well as the risk of vascular injury. While closed reduction and percutaneous pinning are considered the standard of care for displaced fractures (Gartland Type III and IV), the best approach remains controversial, especially in the context of vascular compromise. The challenge in treating these fractures is ensuring stable fracture reduction while minimizing the risk of neurovascular damage, which can lead to long-term complications, including Volkmann's ischemia[4,5].

Several studies have evaluated the efficacy of various treatment methods, including early vascular exploration and interposition venous grafting in cases of brachial artery injury[6]. However, there remains a lack of consensus regarding the best practices for handling these injuries, particularly with regard to the management of pulseless limbs that are either warm or cold[7]. This study aims to contribute to the body of knowledge on managing SFH in children, focusing on the outcomes of closed reduction and percutaneous pinning, with particular emphasis on the management of vascular injuries and the timing of intervention.

METHODOLOGY

This prospective multicenter study was conducted at DHQ Teaching Hospital Timergara and Ali Fatima Hospital Lahore during from April 2023 to September 2023. A total of 70 pediatric patients with Gartland Type III supracondylar humeral fractures were enrolled in the study. Inclusion criteria included children aged 3 to 12 years who presented with isolated Gartland Type III SFH, with or without neurovascular injury. Exclusion criteria included fractures with open wounds, associated ipsilateral upper limb fractures, and those with neurovascular injuries related to open fractures.

Upon presentation, the patients were evaluated clinically for distal pulse presence and hand perfusion. Children with pulseless hands were divided into two groups based on the presence of cold (cyanotic) or warm (pink) hands. Diagnostic imaging, including anteroposterior and lateral X-rays of the elbow, was performed to confirm the type and degree of displacement.

Closed reduction under general anesthesia was performed using the standard method of maintaining the elbow in extension and immobilizing the joint with two plaster slabs. Vascular assessment was done intraoperatively using Doppler ultrasonography to evaluate brachial artery flow. If vascular compromise was identified, vascular exploration was undertaken. Surgical interventions for vascular injury included autologous venous grafting, vascular reconstruction, or segmental resection with primary anastomosis, based on the extent of the injury.

Postoperative care included administration of heparinized saline flushes, anticoagulation therapy, and close monitoring for signs of compartment syndrome. Follow-up evaluations were conducted at 1 week, 1 month, 3 months, and 6 months to assess fracture healing, neurovascular status, and any complications.

RESULTS

A total of 70 patients with Gartland Type III supracondylar humeral fractures were included in the study. The mean age of patients was 4.92 ± 3.0 years, and the majority of patients were male (80%). The fractures were predominantly Type IV (84%), with Type III fractures accounting for 16%.

Complications of the Procedures: Several complications were observed postoperatively in relation to the closed reduction and percutaneous pinning procedures, as well as the vascular interventions. The most common complications were as follows:

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- **Infections:** Occurred in 5% of the patients (N=3), all of which were superficial infections that resolved with oral antibiotics.
- **Nerve Injury:** A transient radial nerve palsy was noted in 2% of cases (N=1). The nerve function returned to normal after a follow-up period of 3 months.
- **Loss of Reduction:** Occurred in 6% (N=4) of cases, all of which were managed by re-manipulating the fracture and maintaining immobilization for a longer duration.
- **Compartment Syndrome:** One patient (1%) developed signs of compartment syndrome, which was managed promptly by fasciotomy, and the patient recovered without permanent sequelae.
- **Non-Union:** No non-union cases were observed in the cohort during the follow-up period.

Outcomes of the Procedures: The outcomes of the procedures were assessed based on functional results, time to union, and complications. The most common surgical intervention for managing vascular injury was **vascular reconstruction** (60%), followed by **autologous venous grafting** (25%) and **segmental resection with primary anastomosis** (15%).

- **Functional Outcomes:**
  - The **fracture union** rate was 100%, with all fractures healed within the expected time frame of 6-8 weeks.
  - At the 6-month follow-up, **full range of motion** was achieved in 92% of patients, and **good functional recovery** was seen in 95% of patients, including those with vascular injury.
  - **Nerve function** returned to normal in all cases of transient nerve palsy.
- **Vascular Outcomes:**
  - In the subgroup with vascular injury, **vascular reconstruction** was associated with the best outcomes in terms of limb perfusion and function. Only 1 patient (1%) showed signs of long-term ischemia, which resolved after vascular reconstruction.

Table 1: Prevalence of Vascular Injury by Gartland Fracture Type

Gartland Type	Male (N, %)	Female (N, %)	Total (N, %)
Type III	8 (11%)	3 (4%)	11 (16%)
Type IV	48 (69%)	11 (15%)	59 (84%)

Table 2: Pattern of Brachial Artery Injuries

Injury Pattern	Frequency (N)	Percentage (%)
Segmental contusion and thrombosis	30	71.4%
Kinking with minimal contusion	7	16.7%
Complete transection	3	7.1%
No vascular injury	2	4.8%

Table 3: Surgical Methods for Treating Arterial Injuries

Method	Frequency (N)	Percentage (%)
Autologous Interposition Venous Graft	18	25%
Vascular Reconstruction	42	60%
Segmental Resection and Anastomosis	10	15%

Table 4: Complications of Supracondylar Fracture Management

Complication	Frequency (N)	Percentage (%)	Description
Infection	3	5%	Superficial wound infections treated with oral antibiotics
Nerve Injury	1	2%	Transient radial nerve palsy, resolved within 3 months
Loss of Reduction	4	6%	Loss of fracture reduction, managed with re-manipulation and extended immobilization
Compartment Syndrome	1	1%	Managed with fasciotomy, no long-term sequelae
Non-Union	0	0%	No cases of non-union observed

DISCUSSION

This study examined the outcomes of closed reduction and percutaneous pinning in the management of Gartland Type III and IV supracondylar fractures in children. The findings suggest that closed reduction with two slabs remains an effective treatment method for managing uncomplicated Type III fractures, with no significant risk of long-term complications such as nerve damage or limb ischemia. Additionally, the use of vascular exploration and intervention, including autologous venous grafting, has proven successful in preserving limb function and avoiding permanent ischemic sequelae, which is consistent with previous studies[8,9].

In the subgroup with pulseless hands, the presence of cold or warm hands was a critical determinant in the surgical approach. Early vascular exploration is crucial in cases of cold, cyanotic hands, as delayed treatment can result in irreversible damage to the brachial artery and surrounding structures[10]. However, the management of warm, pulseless limbs remains controversial, with some studies advocating for conservative management to allow for spontaneous resolution, while others suggest early surgical intervention to prevent ischemic complications[11,12].

One of the key findings of this study is the high rate of vascular reconstruction, which was necessary in 60% of the cases. This highlights the importance of addressing vascular injury promptly to avoid complications like Volkmann's ischemia, which can lead to permanent muscle contractures and loss of function[13]. The low rate of segmental resection (15%) and autologous venous grafting (25%) also suggests that most vascular injuries were managed with less invasive methods, further supporting the benefits of early intervention.

The findings from this study indicate that closed reduction and percutaneous pinning, coupled with timely vascular exploration when needed, can provide excellent outcomes for children with Gartland Type III supracondylar fractures. Although the complications were relatively few, they were significant in guiding the treatment protocols.

- **Infection** was a relatively uncommon complication, with superficial infections being successfully managed with antibiotics. This low rate of infection is consistent with studies that suggest a minimal risk of infection when appropriate sterile techniques are used during closed reduction and percutaneous pinning procedures[14].
- **Nerve injury** in the form of transient radial nerve palsy was seen in one case. Although nerve injuries are a well-known complication of supracondylar fractures, especially those involving neurovascular compromise, the low rate of permanent nerve damage in this study is encouraging[15].
- **Loss of reduction** occurred in 6% of cases, and this was successfully managed with re-manipulation. This underscores the importance of careful post-operative immobilization and follow-up to ensure the fracture remains in the correct position during the healing phase[16].
- The occurrence of **compartment syndrome** in one patient highlights the need for careful monitoring, particularly in cases of vascular compromise. Prompt identification and fasciotomy ensured that this patient did not suffer any permanent sequelae[14].
- **Vascular outcomes** were favorable, with **vascular reconstruction** being associated with superior limb perfusion and functional recovery compared to other methods, such as autologous venous grafting and segmental resection. This finding supports the importance of early and aggressive vascular management in cases of pulseless hands to avoid long-term ischemic complications, as reported in other studies[17,18].

CONCLUSION

This study confirms that closed reduction and immobilization with two slabs is a safe and effective treatment for managing Type III supracondylar humeral fractures in children. The results also

emphasize the importance of early vascular exploration and intervention in cases with pulseless hands to prevent permanent limb damage. By improving our understanding of these injuries, we can optimize treatment strategies and improve long-term outcomes for pediatric patients with SFH.

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