

Management of Vicious Callus of the Distal End of the Humerus in Chad

Daniel Mossalbaye Adedjingue^{1*}, Valentin Andjeffa¹, Magloire Dingamnodje², Allamine Hassan Adoum², Moussa Kalli¹, Service Minguemadji¹, Oswald Goukodadja³, Adoumbaye Djimtolnan¹, Bahar Sougui Haliki¹, Choua Ouchemi¹

¹CHU la Référence Nationale, N'Djaména, Tchad

²Centre Hospitalier Universitaire la Renaissance, N'Djaména, Tchad

³Clinique Universitaire de Traumatologie Orthopédie et de Chirurgie Réparatrice, Centre National Hospitalier et Universitaire Hubert Koutoukou Maga (CNHU-HKM) de Cotonou, Cotonou, Bénin

Email: *dendjinguedaniel@gmail.com, *adendjingue@yahoo.fr

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Abstract

Introduction: Malunion of the distal humerus is a dreaded complication of fractures in this region. It is particularly common in sub-Saharan Africa. The objective of this study was to determine the profile and evaluate the management of these lesions. **Patients and Methods:** This was a retrospective descriptive study conducted over a period of 54 months. It included all patients treated for malunion of the distal humerus with complete medical records. Functional outcomes were assessed using the Mayo Clinic score. Statistical analysis was performed using SPSS 25.0 software (significance threshold $p < 0.05$). **Results:** Twenty-eight patients were included, representing a hospital incidence of 16.86% of humerus fractures. The mean age at diagnosis was 14.5 years, with a male predominance (75%). Playful injuries were the main cause (50%). Initial treatment was predominantly traditional (60.7%). On admission, the most common deformity was cubitus varus (67.9%). Surgically, osteotomy combined with pinning and splinting was the most frequent indication (64.3%). After a mean follow-up of 32.6 months, a statistically significant improvement ($p < 0.01$) in the range of motion, Baumann's angle, and Mayo Clinic score was observed in all operated patients. **Conclusion:** Malunion of the distal humerus in Chad primarily affects children and adolescents, following inappropriate initial traditional treatment. Corrective osteotomy provides excellent anatomical and functional results.

Keywords

Distal Humerus, Malunion, Osteotomy, Traditional Treatment, Chad

1. Introduction

Distal humeral fractures (DHHF) are discontinuities that classically occur below the distal insertion of the brachialis muscle and can be extra- or intra-articular [1]. These fractures represent 2% to 6% of all fractures and nearly 30% of source humeral fractures. They occur in young individuals after high-energy trauma and in older individuals (osteoporotic) after a low-energy fall [2]. The goal of their therapeutic management is to achieve consolidation in the correct anatomical position in order to restore optimal joint function.

However, the absence of satisfactory reduction, inadequate management, or insufficient post-treatment follow-up can lead to complications. Among these complications, malunion remains one of the most feared, due to its functional, aesthetic, and sometimes progressive repercussions [3]. Malunion is defined as the healing of a fracture with one or more deformities resulting in functional consequences [4]. A lack of trained personnel, the absence of referral centers, sociocultural beliefs, and economic barriers contribute to exacerbating this situation [5].

Globally, the incidence of malunion remains variable depending on the context and quality of initial care. The literature reports rates ranging from 10% to 57% of supracondylar fractures in children [6].

In sub-Saharan Africa, the risk of malunion is higher, primarily due to limited access to specialized surgery and treatment delays, according to hospital registries [7].

In Chad, little data are available on malunion of the distal humerus. The aim of this study was to determine the profile and management of malunions of the distal extremity in the Orthopedic and Trauma Surgery Department of the National Referral University Hospital of N'Djamena.

2. Patients and Methods

This was a monocentric retrospective study spanning 54 months, from January 2020 to July 2024, conducted in the Orthopedic Surgery and Traumatology Department of the National Referral University Hospital of N'Djamena. It included all patients admitted to the department for post-traumatic sequelae of the upper limb. Recruitment was exhaustive.

Inclusion criteria were: all patients treated and followed up in the department for malunion of the distal humerus during the study period; those who consented to the study and whose medical records were complete. Patients treated for a lesion other than malunion and those lost to follow-up were not included in the study.

Data collection was performed using a pre-established questionnaire. Data were collected from patients' medical records, consultation and hospitalization logs, and surgical and anesthesia reports.

For the variable data collected, patients were either seen in person or contacted by telephone.

The variables studied were:

- Sociodemographic: age, sex, residence, occupation;

- Anatomical and clinical: medical history, affected side, type of initial injury, functional signs, physical signs, circumstances of onset, injury mechanisms, immediate complications;
- Radiological: types of initial fractures, characteristics of malunion, and associated injuries;
- Therapeutic: time to treatment, type of anesthesia, positioning, surgical approach, type of immobilization, immobilization time, length of hospital stay, and postoperative care;
- Outcomes: postoperative complications, and anatomical and functional outcomes.

Patient history and the presence of a wound or scar overlying the bone lesion allowed the initial injuries to be classified as either closed or open fractures. Classification according to Gustilo and Anderson was not possible. Involvement of the joint was determined using standard radiographs and/or CT scans.

Surgery was indicated for significant angular deformity (between 10° and 20°) or complex deformity involving multiple planes, as well as for significant aesthetic concerns. Following osteotomy, fixation with K-wires was preferred for children or for simple lesions in adults, whereas plate fixation was recommended for adults. Arthrolysis was performed in cases of long-standing injuries with extensive adhesions. For minimal deformities (5° to 10°) that were well-tolerated functionally or for lesions with preservation of joint range of motion (**Figure 1**), a non-surgical approach with monitoring was adopted. Immobilization using an above-elbow splint (brachio-antebrachio-palmar) was employed when K-wire fixation was used. Functional rehabilitation began 48 hours postoperatively following the removal of the drain in cases of plate fixation; in cases of K-wire fixation, it commenced between 21 and 42 days after the removal of the plaster splint.

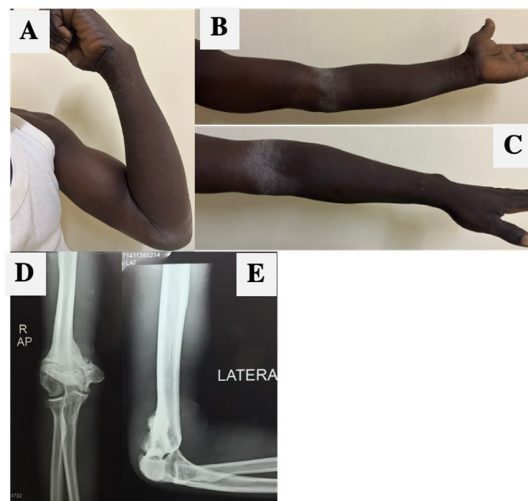


Figure 1. A 39-year-old patient with a malunion of the distal humerus in varus and recurvatum without major functional impairment, for whom surgical abstention was decided.

The results were assessed using the Mayo Clinic Elbow Performance Score [8].

This score evaluates four parameters: pain (45 points), range of motion (20 points), stability (10 points), and daily function (25 points), for a maximum total of 100 points. The clinical outcomes were graded as excellent (≥ 90 points), good (75 - 89 points), fair (60 - 74 points), or poor (< 60 points).

Non-parametric tests were used to analyze the results. Comparisons of radiological parameters, joint ranges of motion, and the Mayo Clinic functional score before and after treatment (paired samples) were performed using the Wilcoxon signed-rank test. Fisher's exact test was applied to the cross-tabulation of qualitative variables with low expected frequencies. The 95% confidence interval (CI) was calculated using the Wilson method. The threshold for statistical significance was set at $p < 0.05$.

The analysis was performed using SPSS version 25.0, and the statistical test used was the chi-square (chi-square) test with a significance level of 5%. The results are presented in tables, figures, and text. They are expressed as percentages and absolute values.

All ethical considerations were respected.

Ethical and Administrative Considerations

To conduct this study, we obtained:

- Research authorization from the Dean's Office of the Faculty of Human Health Sciences, University of Ndjamena (FSSH);
- Administrative authorization from the University Hospital of Ndjamena (CHU-RN).
- Anonymity and confidentiality of the data collected on the patients were respected.

3. Results

During the study, we collected 1705 cases of fractures, including 166 humeral fractures, representing a hospital frequency of 1.6%. Among the humeral fractures, 32 cases of malunion of the distal humerus were noted, yielding a frequency of 19.28% (95% CI: [14% - 25.95%]). **Figure 2** shows the flowchart.

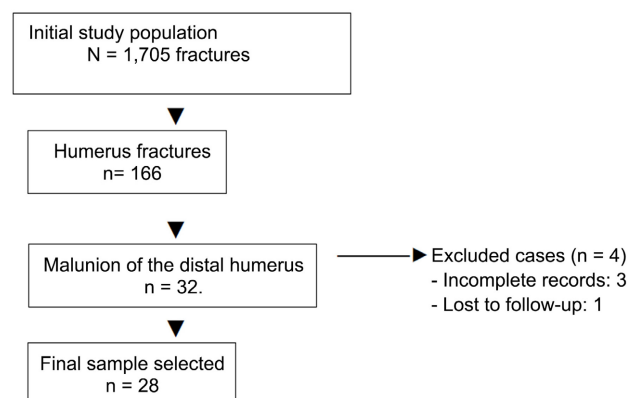


Figure 2. Flowchart.

The mean age of the patients at the time of fracture was 13.4 ± 8.6 years (range: 5 - 41). It was 14.5 ± 8.8 years (range: 6- 42).

The population consisted of 75% (n = 21) men and 25% (n = 7) women (male-to-female ratio of 3). Patients from rural areas represented 57.1% (n = 16) and 42.9% from urban areas (n = 12). The patients were right-sided in 89.3% (n = 25). The injury was located on the left in 20 (71.4%) patients and on the right in 8 (28.6%) others.

The etiology of the initial injuries was as follows: recreational accident (n = 14; 50%), domestic accident (n = 7; 25%), road traffic accident (n = 6; 21.4%), and fight (n = 1; 3.6%).

The mean time to admission was 11.8 ± 4.3 months (range: 3 - 26).

The fractures were closed in 96.4% (n = 27) of patients and open in 3.6% (n = 1). The location of the deformities was extra-articular (n = 23; 82.1%), intra-articular (n = 2; 7.1%), or mixed (n = 3; 10.3%). Mixed median nerve involvement was noted in one patient (3.6%).

The type of initial treatment performed was traditional (n = 17; 60.7%), inpatient (n = 7; 25%), or both traditional and inpatient (n = 4; 14.3%). Inpatient treatment was orthopedic (n = 6; 21.4%) or surgical (n = 1; 3.6%).

The types of deformities observed at admission are shown in **Table 1**. The treatment indications are shown in **Table 2**.

Table 1. Type of intake deformation.

Deformity	Angle between 5° - 10°	Angle between 10° - 20°	Total
Varus	6 (21.4%)	13 (46.5%)	19 (67.9%)
Valgus	3 (10.7%)	5 (17.9%)	8 (28.6%)
Valgus + Recurvatum	0 (0.0%)	1 (3.6%)	1 (3.6%)
Total	9 (32.1%)	19 (67.9%)	28 (100%)

Table 2. Therapeutic indications.

Indications	n (%)
Osteotomy + pin + splint	18 (64.3)
Osteotomy + arthrolysis + pin	3 (10.7)
Osteotomy + plate + splint	5 (17.9)
Observation/Monitoring	2 (7.1)
Total	28 (100)

All patients received postoperative functional rehabilitation. The postoperative outcome was assessed with a mean follow-up of 32.6 ± 8.8 months (range 12 - 8).

Table 3 shows the range of motion for the elbow and for pronation-supination before and after treatment. The comparative values of radiological parameters before and after treatment are presented in **Table 4**. The Mayo Clinic scores at admission and after surgical treatment are listed in **Table 5**.

Table 3. Joint range of motion before and after treatment.

Type of movement	Range of motion (°)	Operated group			Monitored group		
		Before n (%) [IC 95%]	After n (%) [IC 95%]	p-Value (p < 0.05)	Before n (%) [IC 95%]	After n (%) [IC 95%]	p-Value (p < 0.05)
Flexion	<110	26 (100) [87.1 - 100]	-	0.001	-	-	NS
	[110 - 120[	-	5 (19.2) [8.5 - 37.9]	-	-	-	
	[120 - 130[	-	10 (35.7) [22.4 - 57.5]	-	-	-	
	[130 - 140[	-	11 (39.3) [25.5 - 61.1]	-	-	-	
Extension	<0	1 (3.8) [0.7 - 19]	-	0.001	-	-	NS
	[0 - 10[	6 (23.1) [11 - 42.1]	26 [87.1 - 100]	-	2 (100) [34.2 - 100]	2 (100) [34.2 - 100]	
	]11 - 20[	4 (15.4) [6.1 - 33.5]	-	-	-	-	
	> 20	15 (57.7) [38.9 - 74.5]	-	-	-	-	
Pronation	[80 - 90[	-	13 (50) [31.9 - 68.1]	0.001	-	-	NS
	[70 - 80[	2 (7.7) [2.1 - 24.1]	13 (50) [31.9 - 68.1]	-	-	-	
	<70	24 (92.3) [75.9 - 97.9]	-	-	-	-	
Supination	[80 - 90[	-	11 (42.3)	0.001	-	-	NS
	[70 - 80[	-	15 (57.7)	-	-	-	
	<70	26 (100) [87.1 - 100]	-	-	-	-	

Table 4. Comparative evolution of radiological parameters before and after treatment.

Radiological parameter	Value Interval (°)	Operated group			Monitored group		
		Before n (%) [IC 95%]	After n (%) [IC 95%]	p-Value (p < 0.05)	Before n (%) [IC 95%]	After n (%) [IC 95%]	p-Value (p < 0.05)
Baumann angle (NV = 64° - 81°)	<64	8 (30.8) [16.1 - 51.6]	-	0.001	-	-	NS
	[64 - 81]	-	26 (100) [87.1 - 100]	2 (100) [34.2 - 100]	2 (100) [34.2 - 100]	2 (100) [34.2 - 100]	
	>81	18 (69.2) [48.4 - 83.9]	-	-	-	-	
Humero-condylar angle (VN = 30° - 40°)	<30	1 (3.8) [0.7 - 19.0]	-	0.001	-	-	NS
	[30 - 35]	17 (65.4) [46.2 - 80.6]	8 (30.6) [16.1 - 51.6]	-	2 (100) [34.2 - 100]	2 (100) [34.2 - 100]	
	[36 - 40]	8 (30.8) [16.1 - 51.6]	18 (69.2) [48.4 - 83.9]	-	-	-	

Continued

Carrying angle	<5	18 (69.2) [48.4 - 83.9]	-	0.001		NS
	[5 - 15]	-	26 (100) [87.1 - 100]	-	2 (100) [34.2 - 100]	2 (100) [34.2 - 100]
(NV = 5° - 15°)	>15	8 (30.8) [16.1 - 51.6]	-		-	-

(NV = Normal Values).

Table 5. Mayo Clinic functional score before and after surgery.

Mayo Clinic Score	Operated group			Monitored group		
	Before n (%) [IC 95%]	After n (%) [IC 95%]	p-Value (p < 0.05)	Before n (%) [IC 95%]	After n (%) [IC 95%]	p-Value (p < 0.05)
Excellent	-	9 (34.6) [19.4 - 53.8]	0.001	-	-	-
Good	-	15 (57.7) [38.9 - 74.5]	0.001	2 (100) [34.2 - 100]	2 (100) [34.2 - 100]	NS
Fair	24 (92.3) [75.9 - 97.9]	2 (7.7) [2.1 - 24.1]	0.001	-	-	-
Poor	2 (7.7) [2.1 - 24.1]	-	0.001	-	-	-
Total	26 (100)	28 (100)	0.001	-	-	-

4. Discussion

The frequency of malunions of the distal humerus in resource-limited countries, particularly in sub-Saharan Africa, is often related to the socioeconomic context, notably the preference for traditional treatment over conventional medicine [9] [10].

We collected 28 cases of malunions of the distal humerus over 54 months. The hospital incidence of humeral malunions was 16.86% compared to fractures of this region. This finding is similar to data from other African authors [11] [12]. Furthermore, Othman *et al.* [12] found a rate of 12%. Socioeconomic factors such as the use of traditional healers and the scarcity of specialized surgical centers in our context could explain this difference. Overall, this injury remains infrequent in the hospital population (overall hospital incidence was 1.6%).

Our results show a bimodal age distribution, with a large proportion of children (13.4 ± 8.6 years, with a range from 5 to 41 years). However, the presence of adult subjects indicates that malunion of the distal humerus is a multifactorial complication with a bimodal distribution. A Western series also reported a lower mean age in children (5.23 ± 2.45 years) [13].

In this series, the patients' geographic origin was predominantly rural (57.1%), consistent with data from other African authors. This result is in line with that of other authors who have reported a higher figure [14]. This trend highlights the key role of sociodemographic factors in the management of fractures in Africa.

Furthermore, rural populations are more susceptible to treatment delays due to limited access to specialized care. Systematic recourse to traditional therapists as a first resort was noted in the majority of cases. These factors contribute to the long consultation delays observed and significantly worsen the functional prognosis.

Regarding the types of lesions observed in this study, varus deformity was the most common (**Figure 3(A)**, **Figure 3(B)** & **Figure 4(A)**, **Figure 4(B)**) at 67.9%, with 46.5% of these involving an angle greater than 10° . This high rate directly reflects the unstable nature of these lesions, but also, and perhaps more importantly, the often imperfect traditional treatment methods, which include immobilization techniques that do not adhere to basic biomechanical principles [9]. Varus deformities have been the most studied forms in the literature [6] [15]. These deformities cause significant discomfort, particularly during walking, as they are poorly aligned with the pelvic morphology. Joint stiffness, on the other hand, results from prolonged immobilization of the elbow or joint fractures.



Figure 3. Standard anteroposterior and lateral radiographs of a malunion of the distal humerus in an adult; note the varus deformity on the anteroposterior image and the recurvatum deformity on the lateral image.



Figure 4. (A) (B) Standard anteroposterior and lateral radiographs of a malunion of the distal humerus in an 11-year-old child (note the varus deformity on the anteroposterior image and the recurvatum deformity on the lateral image); (C) (D) Radiographic images taken after osteoclasy and osteosynthesis using Kirschner wires in a cross configuration.

From a therapeutic standpoint, osteotomy combined with pin fixation (**Figure**

4(C), Figure 4(D)) and splint immobilization was the most frequently used technique (64.3%), primarily in children. Osteotomy followed by plate stabilization was often the preferred technique in adults. Other authors have reported distal osteotomy combined with pins and a splint as the technique of choice for correcting deformities in children and, under certain conditions, in adults [15] [16].

In this study, mean elbow flexion increased from 97.7° preoperatively to 136.8° postoperatively, and mean extension improved from 17.7° (flexum) to 1.9°. Pronation-supination stiffness was also significantly improved. This good recovery of joint mobility has been similarly observed in other studies, with recovered angular values ranging from 10° to 15° [17]-[20]. These results reflect a satisfactory recovery of the range of motion after surgical correction. The small differences noted between studies can be explained by the methods of postoperative functional rehabilitation, as well as the patients' profiles and ages.

The patients' functional outcomes were assessed using the Mayo Clinic score [8]. The mean score increased from 69.5% to 88.1%, with 92.8% of results being good or excellent. This rate is close to that reported by studies that mentioned 90% and 80% of excellent and good results, respectively, after treatment [18] [21]. These results are consistent with systematic functional rehabilitation and a predominantly pediatric study population with good potential for joint recovery and tissue remodeling.

Statistical analysis comparing different variables before and after treatment showed a highly significant change ($p < 0.05$) in all the clinical and radiological parameters studied. This demonstrates the importance of surgical and postoperative management, as practiced in our center.

Furthermore, the interpretation of these results must take into account the limitations associated with the study's retrospective nature, small sample size, and lack of a control group. A subsequent prospective study involving a larger number of patients is necessary to further investigate these lesions.

5. Conclusion

Malunion of the distal humerus remains a serious complication of fractures in this region. Its frequency is relatively low in our setting, likely due to underreporting. It affects people of all ages, with a marked predominance in children and those from rural areas. Recreational accidents are the primary cause of injury. Delayed initial treatment, incomplete reduction, and the use of traditional home-based techniques are the main contributors to functional sequelae. Treatment is primarily surgical and relies on corrective osteotomy.

Ethical Considerations

Patient consent was obtained for the publication of this article. The ethical principles of the Declaration of Helsinki regarding medical research involving human subjects were adhered to, and approval was obtained from the National Referral University Hospital.

Author Contributions

Conceptualization, Daniel Mossalbaye Adedjingue, Magloire Dingam-Nodje and Valentin Andjeffa; methodology, Daniel Mossalbaye Adedjingue; software Daniel Mossalbaye Adedjingue; validation, Rimtebaye Kimassoum, Valentin Andjeffa, and Daniel Mossalbaye Adedjingue ; formal analysis, Allamine Hassan Adoum; investigation, Adoumbaye Djimtolnan, Service Minguemadji; resources, Daniel Mossalbaye Adedjingue; data curation, Magloire Dingamnodje Magloire Dingamnodje; writing—original draft preparation, Daniel Mossalbaye Adedjingue; writing—review and editing, Daniel Mossalbaye Adedjingue; visualization, Allamine Hassan Adoum; supervision, Rimtebaye Kimassoum ; project administration, Valentin Andjeffa; funding acquisition, Adoumbaye Djimtolnan. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest related to this article.

References

- [1] Ouzaa, M.R., Bennis, A., Zaddouk, O., Zine, A., Tanane, M., Benchakroun, M., *et al.* (2020) Les fractures de la palette humérale: A propos de 45 cas. *PAMJ Clinical Medicine*, **4**, Article 84. <https://doi.org/10.11604/pamj-cm.2020.4.84.26450>
- [2] Kong, G., Mustafa, A., Ajaj, A., Baroudi, O., Alzobi, O., Abuhejleh, H., *et al.* (2025) Fractures de l'humérus distal: Épidémiologie et tendances de prise en charge chirurgicale chez les patients hospitalisés au Qatar. *JSES International*, **9**, 902-906. (In English) <https://doi.org/10.1016/j.jseint.2025.01.005>
- [3] De Crescenzo, A., Garofalo, R., Pederzini, L.A. and Celli, A. (2024) Cal vicieux des fractures humérales distales: Concepts actuels. *Journal of ISAKOS*, **9**, 744-749. (In English) <https://doi.org/10.1016/j.jisako.2024.05.009>
- [4] Abdoulaye, C.A.M.A.R.A., Karim, B.A., Mangué, C.N., Alhassane, B.A.R.R.Y., Moustapha, D.M., *et al.* (2023) Evaluation du traitement chirurgical des cals vicieux des os longs au Service d'Orthopédie-Traumatologie du Centre Hospitalier Universitaire de Donka, République de Guinée. *International Journal of Research Science and Management*, **10**, 12-15.
- [5] Agarwal-Harding, K.J., Amlani, L.M., Ogawa, T., Diallo, M., Patel, K.R., *et al.* (2022) Understanding the Need for Hand and Upper Extremity Surgery in Sub-Saharan Africa: A Survey of Providers. *East and Central African Journal of Surgery*, **27**, 118-132. <https://doi.org/10.4314/ecajs.v27i4.1>
- [6] Miyake, T., Miyamura, S., Miki, R., Shiode, R., Iwahashi, T., Kazui, A., *et al.* (2024) Déformation en varus du cubitus suite à une fracture supracondylienne de l'humérus chez l'enfant: Remodelage prédominant dans le plan sagittal: Analyse tridimensionnelle de quatre-vingt-six cas: Capacité de remodelage de la déformation en varus du cubitus. *International Orthopaedics*, **48**, 2091-2099. (In English) <https://doi.org/10.1007/s00264-024-06197-2>
- [7] Schade, A.T., Mbowuwa, F., Chidothi, P., MacPherson, P., Graham, S.M., Martin, C., *et al.* (2021) Épidémiologie des fractures et de leur traitement au Malawi: Résultats d'une étude de registre prospective multicentrique visant à orienter la planification des soins orthopédiques. *PLOS ONE*, **16**, e0255052. (In English)

- <https://doi.org/10.1371/journal.pone.0255052>
- [8] Score de performance du coude de Mayo (2006) Mayo Elbow Performance Score. *Journal of Orthopaedic Trauma*, **20**, S127. <https://doi.org/10.1097/00005131-200609001-00040>
 - [9] Adedjingue, D.M., Mouassede, M., Madjirebaye, K., Salia, O. and Amoné-Né, D.O. (2022) Complications des traitements traditionnels des traumatismes des membres au CHU Le Bon Samaritain de Walia (N'Djamena, Tchad). *Médecine Tropicale et Santé Internationale*, **2**, 1-12.
 - [10] Mahamat-Nour, A.D., Ngaringuem, O., Lamega, B., Abdoulaye, D., Djian-Noné, K. and Choua, O. (2025) Fracture supracondylienne du coude chez l'enfant à l'hôpital universitaire mère-enfant de N'Djamena. *Open Journal of Orthopedics*, **15**, 359-368. (In English) <https://doi.org/10.4236/ojo.2025.1510036>
 - [11] Hani, R., Nekkaoui, M., Kharmaz, M., Ouadghiri, M.E., Lahlou, A., Lamrani, M.O., et al. (2017) Le traitement chirurgical des fractures de la palette humérale chez l'adulte. *Pan African Medical Journal*, **26**, Article 79. <https://doi.org/10.11604/pamj.2017.26.79.10781>
 - [12] Othman, M.T. and Alany, A.M.S. (2024) Incidence de la consolidation vicieuse dans les fractures supracondyliennes déplacées de l'humérus chez l'enfant après réduction ouverte avec fixation par broche de Kirschner versus réduction fermée avec fixation par broche de Kirschner. *Zanco Journal of Medical Sciences*, **28**, 421-428.
 - [13] Hahn, S.G., Schuller, A., Pichler, L., Hohensteiner, A., Sator, T., Bamer, O., et al. (2024) Complications et résultats des fractures supracondyliennes de l'humérus traitées chirurgicalement chez l'enfant. *Children*, **11**, Article 791. (In English) <https://doi.org/10.3390/children11070791>
 - [14] Abdelraheem, M. (2024) Open Reduction and Fixation of Late-Presenting Pediatric Supracondylar Humeral Fractures: A Prospective Study. *Orthopedic Research and Reviews*, **16**, 221-231. <https://doi.org/10.2147/orr.s474219>
 - [15] Aly, A.S., Mohamed, A.M. and AL Kersh, M.A. (2024) Prise en charge des fractures de la jonction métaphyso-diaphysaire de l'humérus distal chez l'enfant: Revue systématique et méta-analyse. *Journal of Children's Orthopaedics*, **18**, 421-431. (In English) <https://doi.org/10.1177/18632521241262169>
 - [16] Buß, F.R., Schulz, A., Lill, H. and Voigt, C. (2011) Ostéotomies supracondyliennes des déformations humérales distales post-traumatiques chez les jeunes adultes—Technique et résultats. *The Open Orthopaedics Journal*, **5**, 389-394. (In English) <https://doi.org/10.2174/1874325001105010389>
 - [17] Okpara, S.O., Wilson, P.L., Jo, C. and Ho, C.A. (2024) Ostéotomie humérale distale pour cubitus varus chez les enfants comparée à celle des adolescents. *Journal of the Pediatric Orthopaedic Society of North America*, **6**, Article 100022. (In English) <https://doi.org/10.1016/j.jposna.2024.100022>
 - [18] Oka, M.K., Miyamura, M.S., Shiode, M.R., Kazui, M.A., Iwahashi, M.T., Tanaka, M.H. and Murase, M.T. (2024) Three-Dimensional Corrective Osteotomy for Cubitus Varus Deformity Using Patient-Matched Instruments. *JSES International*, **8**, 646-653. <https://doi.org/10.1016/j.jseint.2024.01.005>
 - [19] Sri-UtENCHAI, N., PengrUNG, N., SriKONG, K., Puncreobutr, C., Lohwongwatana, B. and Sa-ngasoongsong, P. (2021) Technologie d'impression tridimensionnelle pour un instrument adapté au patient dans le traitement de la déformation en varus du cubitus: Un rapport de cas. *World Journal of Orthopedics*, **12**, 338-345. (In English) <https://doi.org/10.5312/wjo.v12.i5.338>
 - [20] Xu, W., Fan, Y., Ma, X., Zhang, J., Bi, W., Liu, C. and Wang, W. (2025) Ostéotomie

en miroir simulée par ordinateur dans le traitement de la déformation en varus du cubitus post-traumatique chez l'enfant. *BMC Musculoskeletal Disorders*, **26**, Article No. 537. (In English) <https://doi.org/10.1186/s12891-025-08795-6>

- [21] Anwer, A., Khan, M.J., Asif, N., Raza, A., Harun, F. and Chowdhry, M. (2025) Évaluation des résultats de l'ostéotomie par étapes pour les déformations pédiatriques du cubitus. *Journal des rapports de cas orthopédiques*, **15**, 266.