

"Management of Neglected Lateral Humeral Condylar Fracture by Open Reduction and Kirschner Wires in Children during the COVID-19 epidemic "

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Abstract:

Purpose: Lateral condylar fractures of the distal humerus are the second most common elbow fractures in pediatrics, accounting for up to 5-20%. We aimed to assess the results of displaced, neglected lateral condylar fracture treated with open reduction and internal fixation (ORIF).

Methods: Clinical trial involving 17 patients (aged 3-10 years) treated with Kirschner (K)-wires (January 2020 to January 2024) and followed-up for 2-years.

Results: Patients had a mean age of 6.12 ± 1.99 years, males (70.6%), with mean Bowman's angle of 83.5 ± 5.12 and Liverpool elbow score of 4.2 ± 0.56 . Post-operative decline in Bowman's angle to 77.7 ± 4.2 ($p < 0.001$) and a significant improvement in the Liverpool elbow score reaching 8.02 ± 0.74 ($p < 0.001$). Complications included elbow stiffness (29.4%), scar formation (23.5%), bony spur formation (17.6%), wound infection (11.8%), and avascular necrosis (5.9%).

Conclusion: ORIF using k-wires for neglected lateral humeral condylar fracture could be considered a treatment option with a low rate of persistent limitation of motion.

Keywords: Distal humerus, lateral humeral condylar fracture, opens reduction and internal fixation, elbow stiffness.

Introduction:

Fractures of lateral condylar of humerus are the 2nd most commonly encountered fractures in kids, following supracondylar fractures. They represent seventeen percent of all fractures of distal end of the humerus in kids and 18.5 % of those that happen in upper limb[1-3]. The injury is an intra-articular epiphyseal fracture. In the long term, being diagnosed with Salter-Harris grade 4 correlates with the potential for growth arrest, premature physeal closure, range of motion restriction, angular deformity of the elbow, and neural complications. Kirschner wire fixation and an open reduction are usually utilized to carry out treatment. Positive results are achieved through consistent monitoring [2].

Delayed diagnosis or failed conservative treatment by cast could result in malunion or non-union, leading to angular deformity[4]. The non-union of lateral condylar fractures is probably caused by the lack of bony apposition of the thin lateral condylar fragment and the pull of the forearm extensor muscles. This is especially prevalent if the fractures are managed non-operatively, as fibrosis and displacement around the condylar fragment, which are mechanical forces of common extensor origin, cause a slower healing process [5]. A cubitus valgus deformity is the consequence of the non-united lateral condylar column's lack of supporting and medial condylar's continuous growth [6].

Fear of triggering avascular necrosis (AVN) limits the indications for open reduction and internal fixation (ORIF) in neglected cases. Nevertheless, they encompass tardy ulnar nerve palsy, progressive deformity, loss of function, and pain[7]. The only significant risk factor for AVN is the open reduction of Weiss type III fracture. Type III fractures are a significant risk factor for the progression of non-union [8, 9].

New research has demonstrated that fixation is generally effective in treating non-union, with acceptable union rates, particularly when the operation is carried out in a sixteen-week period [9]. ORIF may be utilized to reduce and stabilize fractures, thereby preserving the posterior periosteum and, as a result, the vascular supply, and preventing epiphyseal plate injury. In addition, an open procedure may be utilized to facilitate the correction of the local biology in particular cases. Autologous bone grafting was recommended [4]. The anatomical reduction must always be tried. Though, it has a high risk of AVN; therefore, the goal in this case is to achieve the best functional reduction. A recommended technique to reduce a displaced fracture is to lengthen the common extensor origin by making multiple incisions along the common extensor aponeurosis[10].

The percentage of cases who achieve adequate or excellent outcomes as determined by functional scores reduces as the time from injury approaches. Cases can be relatively asymptomatic during the delayed presentation. Nevertheless, surgical correction is necessary following consulting with the parents due to the potential for coronal and sagittal plane deformity and neurological sequelae associated with displaced fractures. Good results are expected if proceeded within the first five weeks. Favorable outcomes

decline further. Beyond 12 weeks, progressive displacement is more common, and the probability of risks increases [11, 12]. Fixation without anatomical reduction resulted in a favorable functional outcome with minimal or no pain in the most challenging cases involving an asymptomatic elbow [13]. Delayed presentation and/or non-union are no longer considered contraindications to surgical correction[14]. Nowadays, the presentation of some patients was delayed because of precautions taken during the COVID-19 pandemic, such as cancellation of the routine orthopedic clinics, difficulty traveling between cities, preservation of many hospital beds for COVID-19 patients.

Up to our knowledge, the management results of neglected lateral humerus condylar fractures in kids are underreported in the literature, without evidence-based stand management guidelines. In the current study, we aimed to assess the recovery of elbow function and motion in kids with neglected lateral condylar fracture of the distal end of the humerus through ORIF using K-wires recruited during the COVID-19 pandemic.

Methodology

Study subjects

This interventional case series study was conducted at the Orthopedics and Trauma Department of Suez Canal University Hospital [SCUH], Ismailia, Egypt. The research included 17 children: 12 males and five females presenting to the Orthopedic and Trauma Department with a neglected lateral humeral condylar fracture. Inclusion criteria included patients aged 3-14 years, both sexes, diagnosed with lateral humeral condylar fracture by radiological imaging, presenting later than three weeks and before 16 weeks of injury, and displacement more or than 2 mm.

Cases with multiple skeletal fractures, pathological fractures, open fractures have been excepted from the research. Other exclusion criteria included the presence of elbow dislocation and fractures more than 16 weeks due to increased risk of avascular necrosis [10].

Patient assessment

All patients were subjected to preoperative assessment, including complete history taking, thorough physical examination, and diagnostic investigations. Three radiological views were assessed. For kids with subtle fractures, these consisted of internal oblique, anteroposterior, and lateral comparative radiographs of the contralateral uninjured elbow (**Fig. 1**).



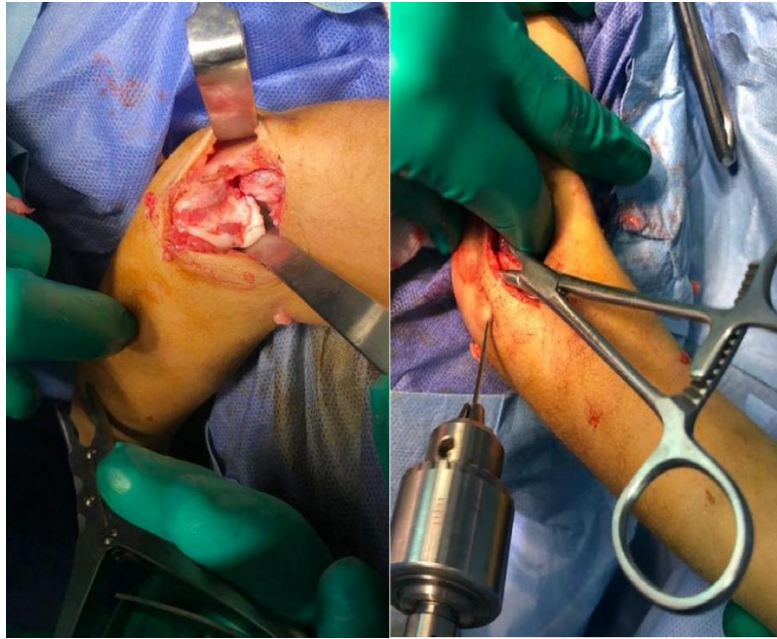
Fig. 1. Plain radiograph of a 6-year-old patient with lateral condylar fracture. (A) Anteroposterior view. (B) Oblique view. (C) Lateral view

Multidetector computed tomography (CT) was demonstrated to be highly precise in the diagnosis of fractures and the evaluation of displacement, as illustrated within **Fig. 2.**



Surgical technique

Under complete aseptic conditions, general anesthesia and tourniquet elevation of the affected limb, a lateral method - Kocher incision- has been made to elbow. Dissection was carried out through plane among brachioradialis and triceps. Lateral fascia was incised to fracture. Subsequently, fragment appeared to be displaced and covered in fibrous tissue, which frequently inhibited the evaluation of the fracture's orientation. The fibrous tissue has been carefully dissected, and the posterior attachments have been preserved (**Fig. 3A-B**).



For eliminating fibrinous debris, extensive irrigation was carried out. For prevent the injury of the posterior blood supply and reduce the risk of avascular necrosis, any dissection required for the lateral epicondyle and metaphysis was performed anteriorly [15].

The operative site was appropriately revealed, and the humeral metaphyseal area has been nibbled to facilitate the simple realignment and rotation of fragments over the posterior soft tissue removal. Occasionally, the articular area has been challenging to distinguish from the metaphyseal region of a condylar fragment due to its proliferation. we conducted an investigation for overhanging cartilage and removed any excess cartilage was trimmed to obtain bleeding metaphyseal bone [16].

The displaced fragment was reduced guided by radiological intensification and under direct visualization, often with the aid of a reduction clamp, “joystick” Kirschner wires, or the assistant’s manual pressure (**Fig. 3C**).



In some cases, the reduction has been problematic. Multiple ‘V’ incisions at the aponeurotic part of the common extensor origin have been done. However, if anatomical reduction still couldn’t be performed, a functional reduction was accepted and better

to avoid AVN. The Kirschner wires we utilized were of 1.4 millimeters in diameter for cases under the age of five, 1.6 millimeters in diameter for those among the ages of 3 and 8, and 1.8 millimeters in diameter for those over the age of 8. Then closure of the wound in layers - periosteum, subcutaneous, and skin -with good hemostasis [15-17].

Post-operative care

Immediate post-operative neurovascular examination and immediate post-operative X-ray were done; anteroposterior, oblique, and lateral views. Following surgery, all cases adhered to a normal regimen of 3 weeks of padded plaster of Paris splint immobilization, after that intermittent range of movement exercises for an additional 3 weeks. The K wire has been eliminated following between six and eight weeks. The cases were permitted to perform range of motion activities with no splint support.

Follow-up and outcome assessment

All patients were followed-up for 2 years, and until now, regarding *Dhillon et al.* and Liverpool elbow score, to assess post-operative function of the elbow [18]. Radiologically avascular necrosis, non-union, malunion, and heterotrophic ossification have been definitely examined. Union has been defined when fracture has been obliterated by callus or trabeculae. A clinical assessment by carrying angle was performed to determine the cosmetic outcome. Radiographical images were evaluated for fishtail deformity, lateral bony spurring, presence of osteonecrosis in the last follow-up visit. to evaluate the overall result, the Liverpool Elbow score [14] and the scoring methodology suggested by Dhillon et al. [18] were utilized.

Statistical analysis

Data was collected in an excel sheet and examined utilizing the Statistical Package for Social Science (SPSS) version 24.0 software. Research results have been defined in tables and graphs. Mean and standard deviation was estimated for each continuous variable. Associations between variables have been tested for significance utilizing the student-t test for continuous variables and the Chi-square test for categorical variables as appropriate. Spearman's correlation analysis was employed, and coefficient correlation was estimated. *P*-values <0.05 have been represented statistically significant.

Results

Baseline characteristics of research people

From January 2020 to January 2024, 17 patients (12 males and five females) with were surgically treated. Their mean age was 6.12 ± 2.0 . Surgical procedure was performed within 5.24 ± 2.3 weeks (ranged 3 to 11 weeks). The motion range was limited from 75° to 90° , and initial Liverpool score was 4.2 ± 0.56 . As demonstrated within **Table 1**, insignificant variance was discovered among males and females regarding their clinical parameters.

Table 1. Baseline characteristics of the study population.

Characteristics	Levels	Total	Female	Male	<i>p</i> -value
Number		17	5	12	
Age, years	Mean ± SD	6.12 ± 2.0	6.2 ± 1.3	6.08 ± 2.27	0.91
	<7 years	11 (0.6)	3 (0.6)	8 (0.7)	0.79
	≥7 years	6 (0.4)	2 (0.4)	4 (0.3)	
Tenderness	Mild	14 (0.8)	3 (0.6)	11 (0.9)	0.19
	Moderate	3 (0.2)	2 (0.4)	1 (0.1)	
Time to presentation, weeks	Mean ± SD	5.24 ± 2.31	4.8 ± 2.49	5.42 ± 2.31	0.63
Flynn's score	Fair	4 (0.2)	2 (0.4)	2 (0.2)	0.53
	Poor	13 (0.8)	3 (0.6)	10 (0.8)	
Dhillon's score	Fair	5 (0.3)	1 (0.2)	4 (0.3)	0.58
	Poor	12 (0.7)	4 (0.8)	8 (0.7)	
Preoperative Liverpool score	Mean ± SD	4.2 ± 0.56	4.02 ± 0.47	4.28 ± 0.59	0.40
Preoperative Bowman's angle, degree	Mean ± SD	83.5 ± 5.12	81.4 ± 5.41	84.4 ± 4.96	0.28

Data is presented as count (percentage) or mean ± standard deviation. Student's t test was used for quantitative variables and Chi-square test was performed to test the difference of categorical variables across groups. *Statistically significant as $p < 0.05$.

Surgical outcomes

Range of motion of elbow significantly improved post-operatively compared to baseline preoperative parameters. **Fig. 4**

A&B.



Fig. 4. Clinical assessment after 2 years shows full range of extension (a) and flexion (b) compared to the other side. Arrow directed to the affected side

The preoperative Liverpool score was 4.2 ± 0.56 , doubled to 8.02 ± 0.74 post-operatively ($p < 0.001$). Radiologically, the mean preoperative Bowman's angle of 83.53 ± 5.12 declined to 77.71 ± 4.22 degrees post-operatively ($p < 0.001$), **Fig. 5A&B**.

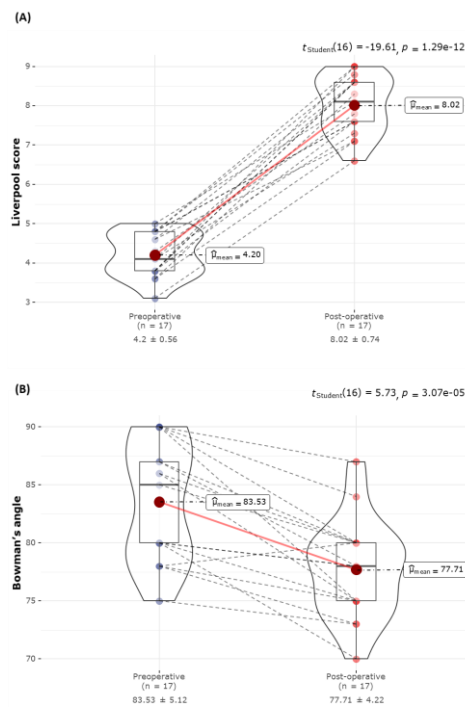


Fig. 5. Assessment of preoperative and post-operative range of motion of the elbow. (A) Liverpool score. (B) Bowman's angle degree. Student's t-test was used. p -values were < 0.001 .

As depicted in **Fig. 6**, correlation analysis showed a negative correlation between patient age and preoperative Liverpool's score ($r = -0.636$, $p = 0.006$). Preoperative Bowman's angle was directly correlated to post-operative Bowman's angle ($r = 0.591$, $p = 0.012$). delayed management was not correlated with surgical outcomes.

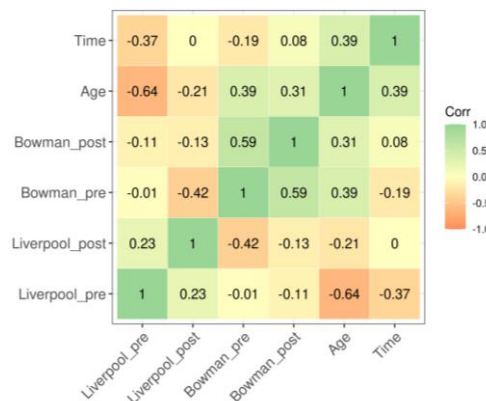


Fig. 6. Correlation matrix showing correlation between clinical parameters. Time: time at presentation after the injury, Bowman: Bowman's score, Liverpool: Liverpool's score, Pre: preoperative, post: post-operative. Spearman's correlation analysis was performed. Correlation coefficient is shown in the figure. Positive values showed direct correlation, while negative values indicated inverse correlation. Stronger correlation has values towards ± 1 . No correlation values are towards zero.

Post-operative complications

Across the study subjects, ten patients (58.8%) developed at least one post-operative complication. Persistent elbow stiffness was present in 5 cases (29.4%). Scar formation was the second common complication accounting for 23.5% of patients (N=4). In addition, three patients (17.6%) developed lateral bony spur, two patients had wound infection, and one case developed avascular necrosis. Comparison between patients who exhibited an improved range of motion and those with persistent elbow stiffness is shown in **Table 2**. And Fig 7 Univariate analysis did not show any significant difference; thus, regression analysis to identify predictors for successful treatment was not feasible.

Table 2. Comparison between patients according to their treatment response.

Characteristics	Levels	Elbow stiffness	Motion recovery	p-value
Number		5	12	
Age, years	Mean \pm SD	7.4 \pm 2.41	5.58 \pm 1.62	0.08
	<7 years	2 (0.4)	9 (0.8)	0.28
	\geq 7 years	3 (0.6)	3 (0.3)	
Sex	Female	1 (0.2)	4 (0.3)	0.58
	Male	4 (0.8)	8 (0.7)	
Tenderness	Mild	4 (0.8)	10 (0.8)	0.87
	Moderate	1 (0.2)	2 (0.2)	
Time to presentation, weeks	Mean \pm SD	6 \pm 3.08	4.92 \pm 1.98	0.39
Poor Flynn's score	Preoperative	3 (0.6)	10 (0.8)	0.53
	Post-operative	3 (0.6)	2 (0.2)	0.11
Poor Dhillon's score	Preoperative	3 (0.6)	9 (0.8)	0.60
	Post-operative	4 (0.8)	3 (0.3)	0.10
Liverpool score	Preoperative	4.26 \pm 0.74	4.18 \pm 0.5	0.78
	Post-operative	7.74 \pm 0.74	8.13 \pm 0.74	0.20
Bowman's angle, degree	Preoperative	86 \pm 4.95	82.5 \pm 5.04	0.33
	Post-operative	77.6 \pm 3.36	77.75 \pm 4.67	0.94

Data is presented as count (percentage) or mean \pm standard deviation. Student's t test was used for quantitative variables and Chi-square test was performed to test the difference of categorical variables across groups. *Statistically significant as $p < 0.05$.

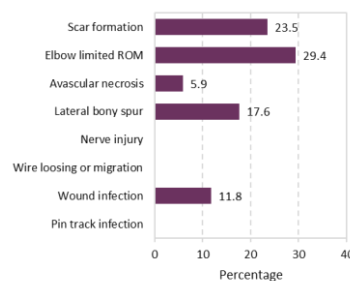


Fig. 7. Post operative complications. ROM: range of motion.

Discussion

Neglected lateral humeral condylar fractures are insufficiently or misdiagnosed managed fractures, presenting later than three weeks following trauma. Inadequate management may cause malunion, delayed non-union or union, and consequently loss of elbow function and permanent angular deformity [1]. The management of certain fractures in kids still a surgical dilemma, with controversy as to whether perform immediate surgical intervention or provide delayed management for complications. A significant disagreement was discovered about optimum timing of fixation, and most investigations lack adequate sample size for drawing satisfactory conclusion.

The current study describes the clinical and radiological outcomes of 17 patients with neglected lateral condyle humerus fracture and displacement of >2 mm, treated by ORIF with K-wire during the COVID-19 epidemic. We hypothesize that K-wire osteosynthesis can be used to enhance elbow function and establish a solid bony union in neglected cases that present following over three weeks of the initial trauma, without the need for bone grafting.

Patients aged 3-10 years were presented at 3 to 11 weeks following the injury. Preoperative elbow function assessment showed an average Liverpool elbow score of four. All patients underwent ORIF with K-wires then followed up for six months. Removal of the k-wires was done after 5- 6 weeks without evidence of fragment displacement. The range of motion assessment was good or excellent in all patients according to both Flynn's and Dhillon's scoring system. Liverpool's elbow score ranged from 6.6 to 9, and Bowman's angle declined to a range of 70° to 87°. On comparing cohorts at different age groups, we found similar outcomes in both old and young children.

In agreement with our findings, a prospective study included 20 lateral humeral condylar fracture patients (12 boys and eight girls) with ages ranging from 3 to 13 years who underwent ORIF with K-wires [19]. After a one-year follow-up, the range of elbow motion enhanced by an average of sixty degrees. Union occurred in 90% of patients within ten weeks [19]. In another study of 21 patients, a significant rise (by forty degrees to eighty degrees) in the full range of flexion and extension movements at final follow-up was noticed in sixteen cases (76.2%), and none of the patients showed any deterioration in the preoperative range of motion [20]. Radiological assessment of the same study subjects demonstrated complete union in all patients within eight weeks [20]. A larger study of 40 pediatric patients presented after three weeks with displaced fractures lateral condyle of humerus Jacob type II/III and underwent ORIF showed union in 97.5% of cases within an average time of 7.8 weeks [21]. Another retrospective study of 21 children with neglected displaced fracture of 3 to 9 mm achieved union in 19 cases (90.5%) and full range of pronation and supination within 6 weeks [22]. In contrast, *Jakob et al.* study showed no improvement following surgical management compared to those without intervention [23], and younger age had a statistically significant but weak impact on results [21].

While late presentation of the fracture can cause management challenges due to fragment displacement, early closure of epiphyseal growth plate, and possibly disruption of condylar blood supply [24], extended time interval among injury and management did not influence the degree of improvement or impacted treatment outcomes in our cohort. Operative treatment of fractures demonstrated favorable functional results, regardless of fractures occurring over twelve weeks post-injury, with an average enhancement in the arc of movement of forty degrees [21]. In contrast, other studies reported adverse results in patients operated after 2 weeks [23], and poor correlation between duration of late presentation and recovered elbow function assessed by Liverpool elbow score [25]. *Saraf and Khare* reported that results of their patients have been improved in those who have been operated upon within eight weeks of injury as well as in those presenting with lesser degree of fragment displacement [20]. Delayed presentation of another 22 pediatric elbow fractures was associated with premature closure of lateral condylar epiphysis and the exact anatomical reduction of the lateral condylar fragment were difficult to achieve [25].

In the present study, our patients developed few post-operative complications; 29.4% had decreased elbow motion, 23.5 % had scar formation, 17.6% had lateral bony spur formation, 11.7% had wound infection, and one patient developed early signs of avascular necrosis. Similarly, *Shabir et al.* [19] reported a minimal post-operative complication rate; 10% developed non-union and 5% had elbow stiffness. *Aggarwal et al.* stated postoperative AVN within one out of twenty-two patients. In another study, 21 patients aged 4 to 14 years [20], malunion was present in 19% of cases, and gross restriction of elbow movement was observed within 14% of cases. Other major complications included pin tract infection in 3 cases and AVN in one case [20].

Our series supports the putative benefits of operating lateral condylar fractures with a delayed presentation. Despite the challenges, fractures can still be managed operatively with good results. Small sample size in our study remains a concern. Larger studies with long-term tracking are warranted to support our findings and define predictors for treatment failure.

Conclusion

Our research adds evidence on the outcomes of surgically managed neglected lateral humeral condyle fractures and clarifies the correlated controversies. Without bone grafting, osteosynthesis using K-wire might enhance elbow function and establish a solid bony union.

Figure legend

Fig. 2. Plain radiograph of a 6-year-old patient with lateral condylar fracture. (A) Anteroposterior view. (B) Oblique view. (C) Lateral view. Fracture line is shown.

Fig. 3. CT of a 6-year-old patient with neglected lateral condyle fracture. (A) 3D image anteroposterior view. (B) Coronal reconstruction. (C) Axial reconstruction. (D) 3D image lateral view. Arrows: the fragmented fracture.

Fig. 3. Surgical procedure. Proper incision and dissection showing (A) Displaced fragment before reduction, necrotic debris removed. (B) After reduction aided by forceps and fixation by K-wires. (C) X-ray after fixation. Reduction of displaced fragment was guided by radiological intensification and under direct visualization.

Fig. 4. Clinical assessment after 2 years. full range of extension (A) and flexion (B) compared to the other side.

Fig. 5. Preoperative and postoperative assessment. (A) Assessment of preoperative and post-operative range of motion of the elbow using the Liverpool score. (B) using Bowman's angle degree. Student's t-test was used. p-values were <0.001. (C) Correlation matrix showing correlation between clinical parameters. Time: time at presentation after the injury, Bowman: Bowman's score, Liverpool: Liverpool's score, Pre: preoperative, post: post-operative. Spearman's correlation analysis was performed. Correlation coefficient is shown in the figure. Positive values showed direct correlation, while negative values indicated inverse correlation. Stronger correlation has values towards ± 1 . No correlation values are towards zero. (D) Post operative complications. ROM: range of motion.

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