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Gradual Correction of Cubitus Varus with the Ilizarov Method: A Retrospective Case Series of 11 Elbows

Filippo Vandenbulcke
IRCCS Humanitas Research Hospital
Marzio Faoro
IRCCS Humanitas Research Hospital
Francesco Manlio Gambaro
IRCCS Humanitas Research Hospital
Luigi Dubini
luigi.dubini@humanitas.it
IRCCS Humanitas Research Hospital
Emiliano Malagoli
IRCCS Humanitas Research Hospital
Alexander Kirienko
IRCCS Humanitas Research Hospital

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Abstract

Background

Cubitus varus most commonly results from malunion of paediatric supracondylar humeral fractures, of which it is the most frequent complication, but it may also be caused by other post-traumatic sequelae, congenital anomalies or metabolic bone disorders. While traditionally regarded as a primarily cosmetic issue, this condition can lead to significant functional problems including chronic pain, ulnar nerve impairment, and posterolateral rotatory instability. The aim of this study was to report the radiographic and functional outcomes and the complications of gradual correction of cubitus varus with the Ilizarov method.

Methods

This retrospective single-centre study included ten patients (eleven elbows) treated with the Ilizarov method between 2006 and 2024 for cubitus varus due to post-traumatic sequelae (n = 9) or X-linked hypophosphataemic rickets (n = 1, bilateral), all operated on by the senior author. The humerus-elbow-wrist (HEW) angle was measured on pre-operative and post-operative radiographs. Patients were assessed pre-operatively and at final follow-up with the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH), the Mayo Elbow Performance Score (MEPS) and the Kerlan-Jobe Orthopaedic Clinic (KJOC) Shoulder & Elbow Score.

Results

Mean follow-up after frame removal was 11.2 ± 6.9 years (range 1.9–20.3). The mean pre-operative varus deformity of 26.0 ± 6.2° (range 15.0–33.2°) was corrected by a mean of 33.2 ± 5.6° (range 25.0–43.2°; $p < 0.001$), resulting in a mean post-operative valgus HEW angle of 7.2 ± 4.1° (range 0–11°). Mean external fixation time was 5.4 ± 1.1 months. The median QuickDASH score improved from 36.4 to 0, the MEPS from 80 to 100 and the KJOC score from 55.1 to 90.1 (all $p < 0.001$). Five adverse events occurred in three elbows (three problems and two obstacles according to Paley); no true complications were observed.

Conclusions

In this series, the Ilizarov method restored physiological alignment, with improved function and no true complications. These results indicate that the technique is a reliable option for cubitus varus of different aetiologies and severities, including deformities not amenable to closing-wedge osteotomy; comparative studies are needed.

BACKGROUND

Varus deformity of the elbow often results from malunited supracondylar fractures, congenital abnormalities, post-traumatic sequelae or bone metabolism disorders (e.g. rickets). It is the most frequent complication of the treatment of humeral supracondylar fractures in children [1].

Although cubitus varus has long been considered a mainly cosmetic problem, the deformity can be severe. Furthermore, the condition is linked to an increased risk of several complications, including lateral condylar fractures, ulnar nerve dislocation, snapping of the triceps tendon, postero-lateral rotatory instability of the elbow, and, rarely, posterior shoulder instability [2].

The correction of varus deformity is particularly complex due to the intricate anatomy of the distal humerus. Among the various surgical approaches, the Ilizarov method has emerged as a versatile and effective technique. This method, which employs a circular external fixator system, allows for gradual and controlled correction of deformities while preserving joint mobility and promoting bone regeneration through distraction osteogenesis. Furthermore, the distal humeral osteotomy can be performed percutaneously, reducing surgical invasiveness [3].

The Ilizarov method is particularly suited to varus elbow deformities, especially in cases complicated by residual deformities, limb-length discrepancies, or previous surgical interventions [3–5]. Its ability to achieve three-dimensional correction with fine adjustments may offer advantages over acute osteotomy with internal fixation, which may be limited by the risk of neurovascular compromise and soft-tissue complications, particularly when large corrections are required [3–5]. Nevertheless, published experience with the Ilizarov method for cubitus varus is limited to a few small series, and data on long-term patient-reported outcomes and on adult patients are scarce [6].

The aim of this study was to report the surgical technique, the radiographic and functional outcomes and the complications of gradual correction of cubitus varus with the Ilizarov method in a single-centre series of ten patients (eleven elbows) with post-traumatic or metabolic deformities of the metaphyseal or epiphyseal region, followed for a mean of more than ten years.

METHODS

Study design and patients

This single-centre, observational, retrospective case series was conducted at the Ilizarov Method Unit of the IRCCS Humanitas Research Hospital, Rozzano (Milan), Italy. We reviewed the medical records of all patients who underwent distal humeral osteotomy with the Ilizarov method to correct a varus deformity of the elbow between January 2006 and December 2024. All patients treated with this procedure were eligible. The only exclusion criterion was an

inflammatory disease at the time of enrolment. No patients were excluded or lost to follow-up during the study period. Ten patients (eleven elbows) were included. Nine had a post-traumatic varus deformity (nine elbows) and one had X-linked hypophosphataemic rickets (bilateral).

The study protocol was approved by the Territorial Ethics Committee Lombardia 5, Rozzano (Milan), Italy (authorisation No. 4759, 19 February 2026). The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice. As the institution is a Scientific Institute for Research, Hospitalisation and Healthcare (IRCCS), all patients, or their parents or legal guardians in the case of minors, signed a consent at hospital admission to the processing of their personal and clinical data for research purposes. Therefore, in accordance with the protocol approved by the Ethics Committee, the study was conducted without the need for any additional consent. The study is reported according to the PROCESS guideline for surgical case series [7].

Ilizarov apparatus and surgical procedure

A reference K-wire was first inserted in the distal humerus and a distal 5/8 ring was fixed to it. Half-pins were inserted after pre-drilling with a cannulated drill bit to avoid neurovascular structures and ensure precise placement. A proximal arch was then fixed to the humeral diaphysis with half-pins inserted under fluoroscopic guidance (Fig. 1). The frame was temporarily decoupled by loosening the connecting rods between the proximal arch and the distal ring, and a percutaneous posterolateral distal humeral osteotomy was performed (Fig. 2). The proximal arch and the distal ring were then reconnected with hinges positioned at the level of the planned axis of correction; the frame configuration was adapted to each deformity. All surgeries were performed by the senior author (A.K.).

Post-operative treatment

After a latency period of 5 days, distraction was started at a rate of 1 mm/day, divided into four increments of 0.25 mm. After the first 7 days of distraction, the angular correction phase began. The rod on the convex (lateral) side of the deformity was no longer lengthened, while the rate of lengthening of the other rods was increased until the proximal and distal rings were parallel. Patients were followed up every 2 weeks during the distraction phase and then every 4 weeks during the consolidation phase. Active elbow motion against gravity was encouraged during the distraction phase, and active movement against resistance was strongly recommended during the consolidation phase. When radiographs showed adequate maturation of the regenerate, a mechanical test was performed by disconnecting the rods between the proximal and distal rings and checking for the absence of motion at the osteotomy site; if the test confirmed bone consolidation, frame removal was scheduled.

Outcome evaluation

Pre-operative and post-operative anteroposterior radiographs were analysed independently by two authors (F.M.G. and M.F.), who drew the reference lines and measured the angles as described by Agrawal et al. [5].

The carrying angle was not used, as it requires radiographs including the entire forearm, which were not available in our study. As suggested by Oppenheim et al., when full-length forearm radiographs were not available, the HEW angle was approximated by the angle formed by the axis of the humeral shaft, the centre of the elbow and the midpoint between the radius and ulna [8].

In case of disagreement, the senior author (A.K.) repeated the measurement to resolve it. Post-operative measurements were performed on radiographs obtained 3 months after frame removal.

Patients were clinically assessed with the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) [9–12], Mayo Elbow Performance Score (MEPS) [13–15] and Kerlan-Jobe Orthopaedic Clinic (KJOC) Shoulder & Elbow Score [16–18] pre-operatively and at final follow-up. All complications were recorded and classified according to Paley as problems, obstacles or true complications [19].

Statistical analysis

Continuous variables are reported as mean ± standard deviation (SD) and range, or as median, interquartile range (IQR) and range when not normally distributed; categorical variables are reported as frequencies and percentages. Normality was assessed with the Shapiro–Wilk test.

Pre-operative and post-operative HEW angles were compared with the paired-samples t-test; results are reported as mean difference with 95% confidence interval (95% CI), and effect size as Cohen's dz. Given the ordinal nature and the ceiling effect of the functional scores, pre-operative and post-operative QuickDASH, MEPS and KJOC scores were compared with the Wilcoxon signed-rank test. Statistical significance was set at $p < 0.05$. Data were collected in Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analysed with Stata version 17 (StataCorp, College Station, TX, USA). A sensitivity analysis including only one elbow of the bilateral case was performed..

RESULTS

Ten patients (eight males and two females; eleven elbows, seven left and four right) with a median age at surgery of 15 years (range 5–63) were included (Table 1). In post-traumatic cases, the median time from injury to surgery was 7.7 years (range 0.7–58.7). Mean follow-up after frame removal was 11.2 ± 6.9 years (range 1.9–20.3). The mean pre-operative varus deformity was 26.0 ± 6.2° (range 15.0–33.2°). After a mean correction of 33.2 ± 5.6° (range 25.0–43.2°; 95% CI 29.4–36.9°; $p < 0.001$; Cohen's dz = 5.92), the mean post-operative valgus angle was 7.2 ± 4.1° (median 10°, range 0–11°) (Fig. 3). The mean external fixation time was 5.4 ± 1.1 months (range 4.1–7.2).

The QuickDASH score (Fig. 4A) decreased from a median of 36.4 (IQR 30.7–42.1) to 0 (IQR 0–10), the MEPS (Fig. 4B) increased from 80 (IQR 72.5–80) to 100 (IQR 95–100), and the KJOC score (Fig. 4C) increased from 55.1 (IQR 53.6–60.8) to 90.1 (IQR 85.5–100) (all $p < 0.001$, Wilcoxon signed-rank test; Table 2). The results were unchanged when only one elbow of the bilateral case was included.

Table 1
Demographic and treatment characteristics of the cohort.

Characteristic	Value
Patients / elbows	10 / 11
Sex (male / female), n (patients)	8 / 2
Side (left / right), n (elbows)	7 / 4
Aetiology (post-traumatic / XLH*), n (elbows)	9 / 2
Age at surgery, years (patients)	15 (11–21.5) [5–63]
Time from injury to surgery, years (post-traumatic elbows)	7.7 (5.0–21.7) [0.7–58.7]
External fixation time, months	5.4 ± 1.1 (4.1 to 7.2)
Follow-up after frame removal, years	11.2 ± 6.9 (1.9 to 20.3)
Problems / obstacles / true complications, n	3 / 2 / 0

Values are n, mean ± SD (range) or median (interquartile range) [range]. *XLH: X-linked hypophosphataemic (vitamin D-resistant) rickets, bilateral case.

Complications were classified according to Paley as problems, obstacles or true complications [19]. A total of five adverse events were recorded in three of the 11 elbows (Table 3). There were three problems, all resolved without further surgery: two pin-tract infections, which resolved with local pin-site care, and one wound dehiscence at a half-pin site after frame removal, which healed completely after two months of local dressings. There were two obstacles, both requiring an additional surgical procedure: one revision of the surgical wound for adhesions ten months after frame removal, and one re-osteotomy for premature consolidation of the osteotomy during the distraction phase. Both obstacles resolved without permanent sequelae. No true complications occurred: there were no neurovascular injuries, deep infections, nonunions, refractures or residual deformities.

Table 2
Radiographic and functional outcomes (n = 11 elbows).

Variable	Pre-operative	Final follow-up	Difference, mean ± SD	95% CI of difference	p value	Test
Radiographic outcome						
HEW angle, °‡	−26.0 ± 6.2 (− 33.2 to − 15.0)	7.2 ± 4.1 (0.0 to 11.0)	+ 33.2 ± 5.6	+ 29.4 to + 36.9	< 0.001	Paired t-test
Functional outcomes						
QuickDASH (0–100, lower = better)	36.4 (30.7–42.1) [13.6–52.3]	0.0 (0.0–10.0) [0.0–28.3]	−30.5 ± 9.5	−36.9 to − 24.1	< 0.001	Wilcoxon
MEPS (0–100, higher = better)	80 (72.5–80) [65–80]	100 (95–100) [75–100]	+ 20.5 ± 5.7	+ 16.6 to + 24.3	< 0.001	Wilcoxon
KJOC (0–100, higher = better)	55.1 (53.6–60.8) [49.7–74.5]	90.1 (85.5–100.0) [65.0–100.0]	+ 31.8 ± 9.1	+ 25.7 to + 37.9	< 0.001	Wilcoxon

HEW angle values are mean ± SD (range); functional scores are median (interquartile range) [range]. ‡HEW, humerus-elbow-wrist angle: negative values indicate varus, positive values valgus. The difference is calculated as final follow-up minus pre-operative value. CI, confidence interval (t distribution). Results were unchanged when only one elbow of the bilateral case was included (all $p \le 0.002$). QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; MEPS, Mayo Elbow Performance Score; KJOC, Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score.

Table 3
Individual data of the eleven elbows.

Elbow	Pt	Sex	Age (y)	Side	Aetiology	Injury–surgery (y)	Pre-op varus (°)	Post-op valgus (°)	Correction (°)	EFT (months)	Follow-up (y)	QuickDASH		MEPS		KJOC
												Pre	Post	Pre	Post	Pre
1	1	M	11	L	PT	5.0	24.0	10.0	34.0	7.2	20.3	36.4	0.0	80	100	55.7
2	2	M	11	R	PT	2.1	32.0	0.0	32.0	4.7	19.7	40.9	0.0	80	100	49.7
3	3	F	5	L	PT	0.7	29.0	11.0	40.0	4.3	19.3	38.6	10.0	80	95	55.1
4	4	M	16	L	PT	12.3	31.0	0.0	31.0	5.0	17.3	50.0	0.0	65	95	52.0
5	5	M	11	R	PT	7.7	29.4	8.0	37.4	4.1	11.6	43.2	13.6	65	95	55.1
6	6	M	23	L	PT	21.7	33.2	10.0	43.2	5.4	10.1	52.3	28.3	65	75	55.1
7	7	M	29	L	PT	23.3	26.2	5.0	31.2	6.7	6.3	31.8	0.0	80	100	65.9
8	8	M	63	L	PT	58.7	15.0	10.0	25.0	5.7	3.5	13.6	0.0	80	100	74.5
9	9	M	14	R	PT	6.9	15.0	10.0	25.0	4.2	1.9	29.5	0.0	80	100	72.1
10†	10	F	17	R	XLH*	–	24.6	10.0	34.6	6.7	6.0	36.4	10.0	80	100	53.6
11	10	F	16	L	XLH*	–	26.5	5.0	31.5	5.0	6.9	29.5	4.5	80	100	53.6

Pt, patient; F, female; M, male; L, left; R, right; PT, post-traumatic; XLH*, X-linked hypophosphataemic (vitamin D-resistant) rickets; EFT, external fixation time (frame application to removal); PS, pin-site. Follow-up was calculated from frame removal to final evaluation. Age at surgery in completed years. †Additional correction in the sagittal plane. Adverse events classified according to Paley: problems, resolved without further surgery; obstacles, requiring further surgery but resolved; true complications, with permanent sequelae (none in this series).

DISCUSSION

In this series, gradual correction of cubitus varus with the Ilizarov method restored a physiological HEW angle in all elbows and was associated with a significant improvement in all functional scores at a mean follow-up of more than ten years (Fig. 5). Although the small sample size and the absence of a control group do not allow direct comparison with other techniques, these results support the Ilizarov method as an effective and precise option for distal humerus deformities.

Our findings are consistent with previous reports on distraction osteogenesis for cubitus varus. Previous studies have reported that lateral closing wedge osteotomy (LCWO) remains the most widely used technique for cubitus varus deformity correction, yet it has been associated with complications, including neuropraxia and residual prominence of the lateral condyle. The systematic review by Hoffman et al. [20] reported that distraction osteogenesis yielded the highest rate of excellent outcomes among the available techniques, in line with our results. Although superficial pin-site and wound infections have been reported as a concern with external fixation, no deep infections occurred in our cohort [20].

There is ongoing debate regarding the optimal surgical approach to the distal humerus [21], with each approach carrying risks of nerve injury and unsatisfactory scars. In our series, the percutaneous osteotomy performed according to the Ilizarov technique was not associated with any neurovascular injury, a complication reported after LCWO, in which acute correction of the deformity may cause a traction injury [4, 20].

An important advantage of the Ilizarov method is its ability to allow angular correction in multiple planes, accommodating complex deformities that may be challenging to address with traditional osteotomies. Cubitus varus is a three-dimensional deformity, often also involving extension and internal rotation of the distal humerus [22]. Our series included one elbow that required additional correction on a secondary axis, illustrating the adaptability of the method to multiplanar deformities [23].

Although 3D reconstructions of cubitus varus have been documented [24], these techniques require CT-based planning and patient-specific guides, which result in higher medical costs and increased radiation exposure: issues of particular concern in pediatric patients.

Our series included both metaphyseal and epiphyseal deformities. In epiphyseal deformities, the osteotomy must be performed proximal to the CORA. According to the osteotomy rules [25], to avoid secondary translation deformity between the proximal and distal axes, angulation and translation at the osteotomy site are required. With the Ilizarov method, the frame hinges can be placed at the level of the CORA, which can be verified both clinically and radiographically, so that the angular correction occurs with the appropriate translation. With acute correction, a comparable result can be obtained only with step-cut osteotomies, which require more complex planning [26].

The ability to perform gradual correction using an external fixator provides enhanced control over alignment, reducing the risk of over- or undercorrection, since alignment can be checked and adjusted during the correction phase. Moreover, the stability of the frame allows early elbow mobilisation without cast immobilisation, which is usually required after conventional osteotomy with K-wire fixation [27].

Despite its advantages, the Ilizarov technique is not without challenges. The frame must be worn for several months (mean 5.4 months in our series), requires frequent follow-up visits and pin-site care and high patient compliance, and may be poorly tolerated, particularly by children, compared with the shorter treatment of a closing-wedge osteotomy [26].

Several of our patients presented an associated articular deformity, consistent with the findings of Cha et al., who demonstrated that greater degrees of cubitus varus were associated with increased proximal ulnar varus and a younger age at the time of injury, indicating that earlier surgical correction might help prevent morphological alterations of the elbow. For the same reason, corrective osteotomy of the distal humerus is technically less demanding in children than in older patients. Even after multiplanar correction with the Ilizarov frame, these intra-articular abnormalities persist, as they cannot be addressed by an extra-articular osteotomy [28].

This study has several limitations. First, its retrospective design, the small sample size and the absence of a control group limit the strength of the conclusions and do not allow comparison with other techniques. Second, the cohort was heterogeneous in terms of age (5–63 years), aetiology and deformity location, and the bilateral case contributed two non-independent elbows to the analysis. Third, follow-up was variable (1.9–20.3 years), so late recurrence or growth-related changes could not be assessed in all patients. Fourth, the deformity was assessed only in the coronal plane on plain radiographs, without quantification of the sagittal and rotational components, and the radiographic measurements were not blinded. Nonetheless, our findings provide encouraging evidence that distraction osteogenesis with the Ilizarov apparatus represents a viable and effective alternative for managing varus elbow deformities, especially in cases where complex metaphyseal and epiphyseal deformities preclude the use of classical osteotomy techniques in accordance with CORA principles.

Future prospective, multicentre comparative studies with larger cohorts are needed to further validate the long-term efficacy of the Ilizarov method in comparison to other surgical approaches, and to establish standardized protocols for its application.

CONCLUSIONS

This case series suggests that gradual correction of varus elbow deformity using the Ilizarov method can effectively restore physiological alignment and improve functional outcomes without true complications. Radiographic assessment confirmed a reliable correction, which, together with the functional improvement observed, supports the procedure as a valuable option for complex cubitus varus deformities. Further comparative studies with larger populations are needed to define its indications relative to other osteotomy techniques.

Abbreviations

CI
confidence interval
CORA
centre of rotation of angulation
HEW
humerus-elbow-wrist
KJOC
Kerlan-Jobe Orthopaedic Clinic
LCWO
lateral closing-wedge osteotomy
MEPS
Mayo Elbow Performance Score
QuickDASH
Quick Disabilities of the Arm, Shoulder and Hand
SD
standard deviation.

Declarations

Ethics approval and consent to participate:

The study protocol was approved by the Territorial Ethics Committee Lombardia 5, Rozzano (Milan), Italy (authorisation No. 4759, 19 February 2026). The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice. As the institution is a Scientific Institute for Research, Hospitalisation and Healthcare (IRCCS), all patients, or their parents or legal guardians in the case of minors, signed a consent at hospital admission to the processing of their personal and clinical data for research purposes. Therefore, in accordance with the protocol approved by the Ethics Committee, the study was conducted without the need for any additional consent.

Consent for publication:

Written informed consent for the publication of clinical images and radiographs was obtained from the patients or, for minors, from their parents or legal guardians.

Competing interests:

The authors declare that they have no competing interests.

Clinical trial number

Not applicable

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Author Contribution

F.V: data collection, drafting of the manuscript; M.F and F.M.G: radiographic measurements and data analysis; L.D: critical revision; E.M: data interpretation; A.K: surgeon, study conception and supervision. All authors read and approved the final manuscript.

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Data Availability

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

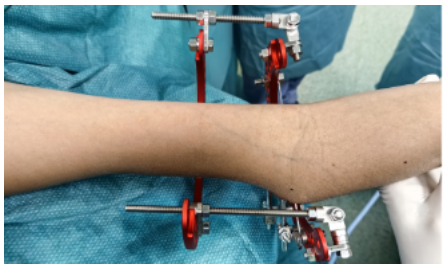


Figure 1

Intraoperative view during frame construction. Note the level of the hinges.



Figure 2

Intraoperative view showing the percutaneous distal humerus osteotomy performed with an osteotome.

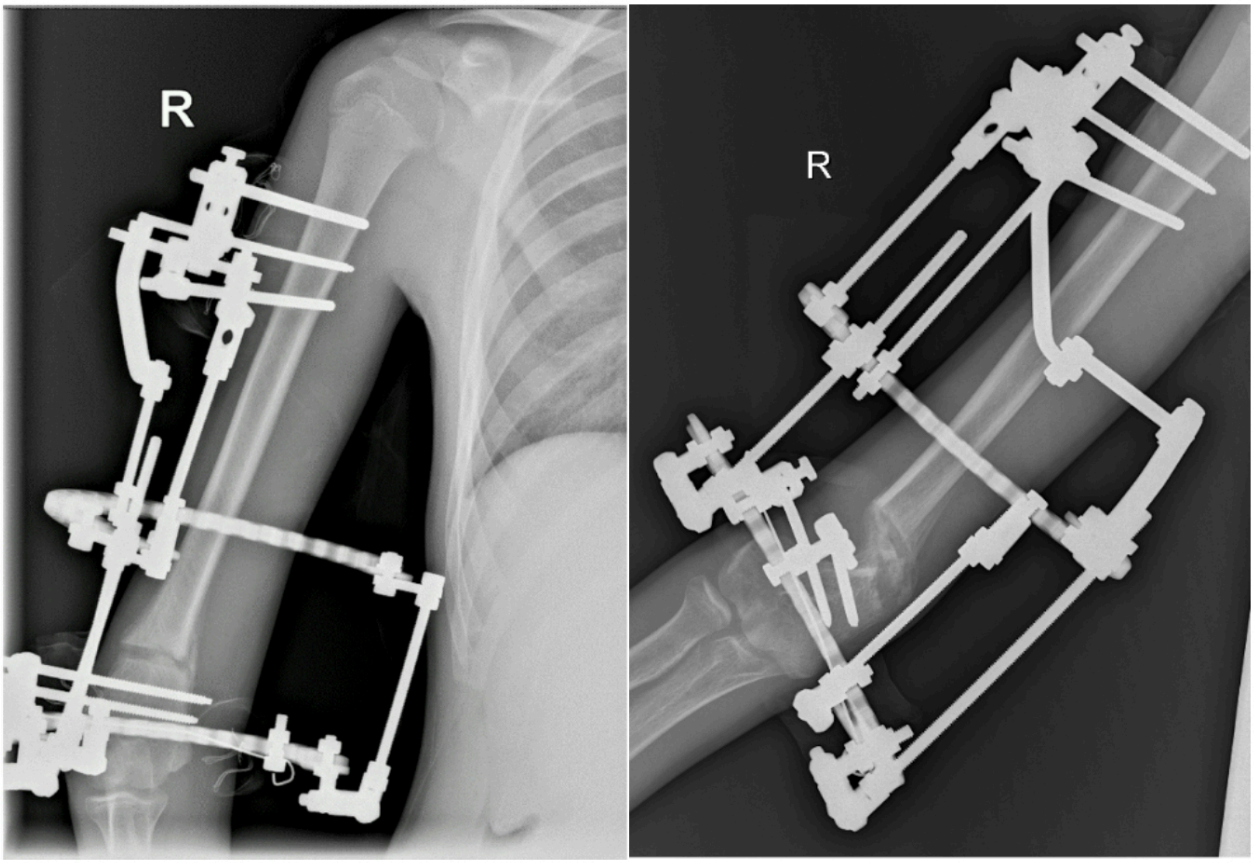


Figure 3

Pre-operative and post-operative anteroposterior radiographs of a representative case.

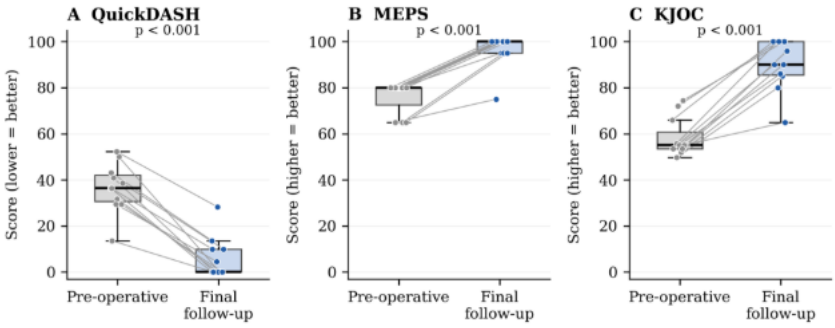


Figure 4

Comparison of pre-operative and post-operative A) QuickDASH, B) MEPS, and C) KJOC scores. Box plots show median and interquartile range, whiskers the range; lines connect the values of each elbow.

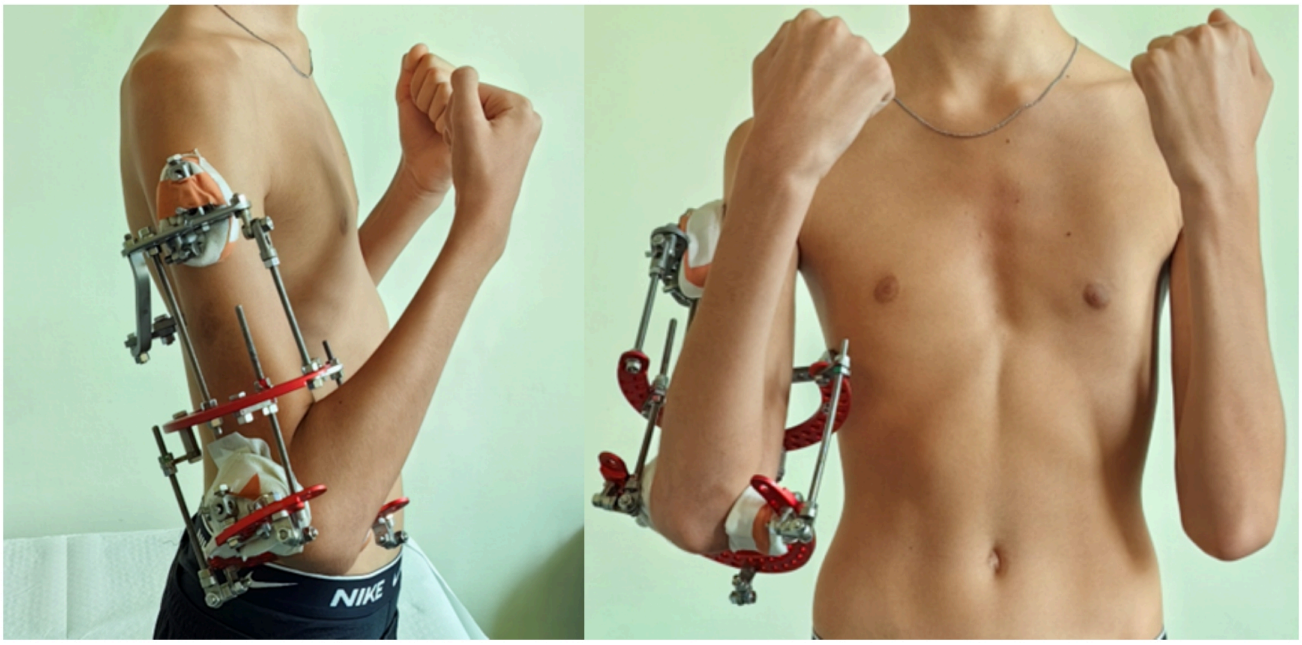


Figure 5

Clinical appearance of a patient during treatment with the Ilizarov frame.