Quick-DASH as a main early outcome of humeral shaft fractures: A Latin American multicenter prospective study

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Abstract

Purpose: The main objective of this study was to evaluate the Quick-Disabilities of the Arm, Shoulder and Hand Score (DASH) score as the main early (90 days) outcome in a prospective multicenter observational Latin American study on isolated humeral shaft fractures. Methods: From December 2015 to April 2017, in six Latin American countries, patients 18 years or older with a closed, isolated nonpathological 12A, 12B, or 12C AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) fractures were included. The 90 (+10)-day Quick-DASH score was used to compare the results of the different treatments. The secondary outcomes were patient treatment satisfaction, shoulder and elbow range of motion, and radiographic evaluation. Results: A total of 92 patients successfully completed the Quick-DASH questionnaire. Surgical treatments resulted in better outcomes than nonsurgical treatment, but only minimally invasive plate osteosynthesis produced significantly lower Quick-DASH scores than nonsurgical treatment (p < 0.05). There were strong correlations between patient self-evaluation and the Quick-DASH score (p < 0.0005) but not between the Quick-DASH score and radiographic fracture healing. No significant difference was found between the treatments regarding the rate of return to work, but the medical center had a significant influence on treatment choice (p < 0.0005). Conclusion: The high correlation between Quick-DASH score and patient satisfaction and functional outcome indicates that the Quick-DASH questionnaire is a suitable tool for evaluating adult humeral shaft fracture outcomes. Patients with a Quick-DASH score below 15 could be considered recovered, and patients with a Quick-DASH score above 40 could be considered not yet recovered. Quick-DASH scores were not significantly associated with radiographic fracture healing.

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Introduction
Humeral shaft fractures have an incidence of 12.9 to 19/100,000/year.\(^1,2\) Nonsurgical treatment is considered the method of choice for isolated humeral shaft fractures.\(^3\) However, the most recent literature has pointed to the use of surgical treatments like minimally invasive plate osteosynthesis (MIPO), closed reduction and fixation with a locked intramedullary nail, and open reduction and internal fixation with a plate (ORIF), especially because they allow for a quicker return to work and leisure activities and provide better cosmetic results.\(^4,5\)
Given the lack of any relevant epidemiological study about humeral shaft fractures in Latin America, a prospective multicenter observational study was conducted with 10 medical institutions in 6 Latin American countries. The primary objective of the study was to assess the treatment outcomes by means of the Quick-DASH score. In a previous article,\(^6\) the demographic and clinical findings of 123 patients enrolled in the study were presented. This article presents the associations of the 90-day Quick-DASH questionnaire with fracture characteristics, type of intervention, and treatment outcomes.

Materials and methods
The registration, ethics aspects, study design, inclusion and exclusion criteria, intervention, and fracture treatment are identical to those described in Belangero et al.\(^6\)

Registration and ethics
The study was conducted according to the ethical principles outlined by the Declaration of Helsinki and according to the laws and regulations of the participating countries. Ethics approval from all local authorities was obtained. The coordinating center was located at the University of Campinas’ School of Medical Sciences, Campinas, Sao Paulo, Brazil, and the approval of the project was given the following identifier: CAAE Approval—1.142.071, July 2, 2015.

Study design
This was a prospective multicenter observational study of humeral shaft fractures involving 11 different medical institutions in 6 Latin American countries, namely, Argentina (1), Brazil (4), Colombia (2), Guatemala (1), Uruguay (1), and Venezuela (2). Ten of the institutions were dedicated to treating public patients (five were associated with universities), and one was a military hospital. The study site staff entered all source data into a Web-based electronic data capture system, which was sponsored by the AOLAT (AO Trauma Latin America). Patients were enrolled between December 17, 2015 and April 16, 2017.

Inclusion criteria
Inclusion criteria include age of 18 years or older; closed, isolated humeral shaft fracture (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) 12A, 12B, 12C) confirmed by radiographic evaluation; primary surgical treatment of the fracture within the first 20 days after the trauma; absence of previous fracture treatment; and ability of the patient or his/her legally authorized representative to understand and sign the informed consent form.

Exclusion criteria
Exclusion criteria include articular fracture with diaphysis extension, open fracture, polyfractured or polytraumatized patient, pathological fracture, neurological and/or psychiatric disorders that prevent a reliable evaluation (e.g. Parkinson’s disease, multiple sclerosis, and severe depression), imprisonment, previous implant in the fractured limb, and treatment of fracture initiated 3 or more weeks after injury.

Informed consent
Patients or their legal representatives were informed about their voluntary participation, right to withdraw, contact for questions and complains, risks and benefits, data privacy, and the purpose of the study.

Intervention
Patients who participated in this study received treatments and postoperative care according to the standard practice of each individual clinic, and the routine protocol of treatment was followed according to the preference of the surgeon.

Data collection
All patients were clinically followed whether the bone healed or not, and after 90 (± 10) days, a comprehensive evaluation (Quick-DASH questionnaire, shoulder and elbow range of motion, X-ray evaluation, and treatment
satisfaction) was performed. Patients with two or more unanswered questions were excluded. A webinar meeting with all participants was performed at the beginning of the study to explain how the final evaluation should be done, how to answer the Quick-DASH questionnaire, and how to measure elbow flexion and extension angles, shoulder elevation, and external and internal rotation. All these examinations were performed bilaterally (left and right) using a goniometer. To minimize observer bias, angle values were determined by considering the delta value between the fractured and the nonfractured sides.

Based on the radiographic evaluation, the fracture was considered healed if there was callus formation in at least three cortices in orthogonal views. Using anteroposterior and posterior X-ray views, varus–valgus deviation, limb-length shortening (P-view), and ante- and recurvatum were measured.

Whether the patient could put their hand on their neck and on their interscapular region (yes or no) was determined by patient self-evaluation but without any kind of measuring.

Patient satisfaction was investigated through the following questions: Do you feel able to return to work? Do you feel the fractured limb is identical to that on the nonfractured side? Would you choose the same treatment in case of a new fracture? Did you return to your recreational and sports activities? What is your pain level on a visual analog scale (0–100)?

Outcome measures

The Quick-DASH score was used to compare the results of the different types of treatment and with the secondary outcomes (radiographic evaluation, patient treatment satisfaction, and shoulder and elbow range of motion).

Statistical analysis

The influence of the type of treatment (intramedullary nailing, MIPO, ORIF, and nonsurgical) on the final Quick-DASH score and on the secondary outcomes was investigated. Data distributions were tested for normality. Data that were normally distributed were analyzed using Student’s t-test. Nonnormally distributed data were analyzed using the Mann–Whitney U test in the case of two groups or the Kruskal–Wallis test in the case of three or more groups of data. Pairwise comparison of numeric data was performed with the Dunn–Bonferroni post hoc test. For categorical data, the Mann–Whitney U test was applied to each pair individually, and the p values were divided by the number of pairs. The influence of the medical center and the type of fracture on the choice of the treatment was analyzed with the χ² test. All results were considered significant at p < 0.05. The statistical software used was SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA).

| Demographic/clinical factors | Treatment |
|-----------------------------|-----------|
| Sex                         | IMN MIPO ORIF NSUR Total |
| Male                        | 4 25 12 9 50 |
| Female                      | 19 6 9 8 42 |
| Age (years)                 | 18–40 5 20 11 10 46 |
|                             | 41–65 6 8 7 4 25 |
|                             | >65 12 3 3 3 21 |
| Sports activities           | Yes 3 18 8 4 33 |
|                             | No 20 13 13 13 59 |
| Smoking                     | Yes 2 9 5 2 18 |
|                             | No 21 22 16 15 74 |
| Chronic medication use      | Yes 8 4 2 7 21 |
|                             | No 15 27 19 10 71 |
| Fracture energy             | Low 16 22 12 7 57 |
|                             | High 7 9 9 10 35 |
| AO classification           | 12A 14 16 14 7 51 |
|                             | 12B 4 12 6 9 31 |
|                             | 12C 5 3 1 1 10 |
| Fracture level              | Proximal 3 3 2 4 12 |
|                             | Middle 19 22 12 7 60 |
|                             | Distal 1 6 7 6 20 |
| Total                       | 23 31 21 17 92 |

IMN: intramedullary nailing; MIPO: minimally invasive plate osteosynthesis; ORIF: open reduction internal fixation; NSUR: nonsurgical treatment; AO: Arbeitsgemeinschaft für Osteosynthesefragen.

Results

Of the 123 patients considered in the demographic and clinical study, 92 patients (75%) correctly completed the Quick-DASH questionnaire and were distributed as follows: Brazil (n = 34), Argentina (n = 20), Venezuela (n = 16), Colombia (n = 12), Guatemala (n = 6), and Uruguay (n = 4). The demographic and clinical data of the 92 patients considered in this article differ slightly from those in the first article and are presented in Table 1.

Main outcome: Quick-DASH score

Figure 1 shows a comparison between the Quick-DASH score obtained for each type of intervention. MIPO patients obtained the lowest scores (median = 2.2, 1st quartile = 0.0, 3rd quartile = 18.2), followed by ORIF (median = 10.0, 1st quartile = 0.0, 3rd quartile = 22.7), intramedullary nailing (median = 22.7, 1st quartile = 9.5, 3rd quartile = 29.1), and nonsurgical treatment (median = 25.0, 1st quartile = 6.8, 3rd quartile = 59.1) patients. Statistical analysis showed a significant difference only between
The median score for all patients was 13.6 (1st quartile = 0.0, 3rd quartile = 27.8).

Table 2 presents the final Quick-DASH scores according to radiographic consolidation and patient self-evaluation. The responses to all four self-evaluation questions exhibited a strong correlation with the Quick-DASH scores, with the scores of the patients with negative self-evaluation being markedly higher than those of the patients with good self-evaluation ($p < 0.0005$). No significant association was found between the radiographic evidence of consolidation and the Quick-DASH score.

**Secondary outcomes**

**Radiographic evaluation.** After 90 ($\pm 10$) days, X-ray evaluation showed 95.7% consolidation for intramedullary nailing, 64.5% consolidation for MIPO, 86.7% consolidation for ORIF, and 64.7% consolidation for nonsurgical treatment. A statistically significant difference ($p < 0.05$) was found between intramedullary nailing and MIPO (Table 3).

**Patient treatment satisfaction and patient self-evaluation.** Significant differences were found between nonsurgical treatment and ORIF ($p < 0.01$), nonsurgical treatment and MIPO ($p < 0.05$), and nonsurgical treatment and intramedullary nailing ($p < 0.05$) regarding returning to sport and recreation activities. No differences were found for hand on the neck or interscapular region, for feeling able to return to work or if the fractured limb was equal to the nonfractured limb (Tables 2 and 3). The Kruskal–Wallis test indicated a significant difference in the willingness to undergo the same treatment again, but this result was not confirmed by post hoc tests. Significant differences were found between nonsurgical and the three surgical treatments for returning to sport and recreation activities.

**Shoulder and elbow range of motion.** No significant differences were found between the three surgical treatments regarding elbow flexion and extension, shoulder elevation, external and internal rotation, valgus and varus deviation, humerus shortening, and antecurvatum and recurvatum.

The following median values were significantly higher for nonsurgical treatment compared to each of the surgical treatments: valgus/varus deviation (nonsurgical $= -10^\circ$, intramedullary nailing/MIPO/ORIF $= 0^\circ$, $p < 0.001$), shoulder external rotation (nonsurgical $= -10^\circ$, intramedullary nailing/MIPO/ORIF $= 0^\circ$, $p < 0.05$), humerus shortening P-view (nonsurgical $= 1.0$ mm, intramedullary nailing/MIPO/ORIF $= 0.0$ mm, $p < 0.05$), and antecurvatum/recurvatum (nonsurgical $= 5^\circ$, intramedullary nailing/MIPO/ORIF $= 0^\circ$, $p < 0.01$).

Significantly higher values of $\Delta$-elbow flexion were also found for nonsurgical treatment in comparison to MIPO and ORIF ($-5^\circ$ vs. $0^\circ$, $p < 0.05$) and of $\Delta$-shoulder elevation in comparison to MIPO ($-20^\circ$ vs. $0^\circ$, $p < 0.05$). No significant differences between treatments were found for $\Delta$-elbow extension, $\Delta$-shoulder internal rotation, or pain level between the three surgical options.

**Additional results**

Table 4 presents the number of cases according to treatment type, fracture type, and medical center. Only data from centers that included at least five cases are shown in the table. A strong influence of the center on treatment choice was found ($p = 0.000$), but no influence of the fracture type.
was found ($p = 0.172$). Six different nails were used in the 23 intramedullary nailing cases. MultiLoc® was the most commonly used nail (11 cases), and in three cases, the fracture focus needed to be opened. In two cases, a lack of contact between fragments and inadequate fracture reduction was observed. Eighteen fractures were treated by MIPO with an LCP®, 11 with a DCP® narrow, and three with a DCP broad. Concerning RAFI, nine cases received an LCP, six received a DCP narrow, two received a DCP broad, and four did not report this information.

Table 5 shows the complications according to the type of surgical treatment.

### Discussion

This study was designed to assess the panorama of humeral shaft fractures in Latin America without any formal...
hypotheses to be tested. Although very few studies involving humeral shaft fractures in adults that used Quick-DASH were found,7–9 its relatively widespread use (including DASH) in evaluating functional clinical outcomes of different orthopedic and nonorthopedic disorders10 suggested that this score could be suitable as the primary outcome of humeral shaft fractures.

In this study, the Quick-DASH score showed a significant difference between MIPO and nonsurgical treatment, with better scores for MIPO, confirming the results obtained by Matsunaga et al.11 However, no significant differences were found between MIPO and the other surgical treatments or between intramedullary nailing/ORIF and nonsurgical treatment (Figure 1). Regarding angles and deviations, all surgical methods had, in general, better results than nonsurgical ones, but this superiority was not expressed in the patient’s self-evaluation, except in relation to the return to sports and recreational activities and in positioning the hand on the neck or the interscapular region. These results coincide somewhat with the controversy in the literature about the superiority or nonsuperiority of surgical treatments, with reports of higher rates of delayed union and nonunion for nonoperative treatment12 and of similar consolidation time for both types of treatment.13 It is important to stress that, despite this controversy and its inferior outcomes according to some criteria, nonsurgical treatment continues to be a good option to treat isolated humeral shaft fractures.

The results presented in Table 2 show a strong correlation between Quick-DASH scores and patient self-evaluation (p < 0.0005), confirming the suitability of using this criterion as a primary outcome of adult humeral shaft fractures, even though there is no consensus on the value of the score that would define a successful treatment.14 The DASH and Quick-DASH outcome measures e-bulletin,15 based on third-party studies, suggested that scores below ~15 would indicate “no problem” for the patient, between ~15 and ~40 would indicate “problem but working” and above ~40 would indicate “unable to work”. These numbers agree with the data shown in Table 2; that is, the Quick-DASH score medians and 3rd quartiles for the positive evaluations were always below 10 and 25, respectively, and the 1st quartile for the negative evaluations were always above 15. Therefore, it could be admitted that patients with Quick-DASH scores below 15 were completely recovered and patients with Quick-DASH scores above 40 had problems, with an unclear zone between 15 and 40.

A significant difference was found between the radiographic healing rate associated with intramedullary nailing and MIPO (Table 3). Because there is no consensus on an objective criterion for the definition of humeral shaft radiographic consolidation16 and the study outcomes do not suggest functional inferiority of MIPO relative to intramedullary nailing, it can be concluded that the criterion used (three cortices) may have been too tough.

Although the literature recommends the choice of treatment according to the characteristics of the fracture,4,17 no correlation between these two factors was found in this study (Table 4). In fact, it has been found that the type of treatment is strongly dependent on the preference of each medical center (p < 0.0005).

One important strength of the study was that it was the first multicenter, prospective observational in Latin America. On the other hand, its main limitation was the loss of patients during follow-up. Difficulties in clinical research that are usually found in this region18 contributed to the fact that, from the 123 patients included in the demographic and clinical study,5 it was only possible to complete the protocol with 92 patients. Due to specific problems in some countries, it was not possible to follow-up all patients for 90 days, as stated in the study protocol. In some regions more affected by social and economic deficiencies, it is not uncommon for patients to stop returning to the medical service, whether due to economic constraints or difficulty with transportation, as soon as they feel sufficiently recovered to return to work.

Another limitation was the lack of identical rehabilitation protocols as well as the application of questionnaires and patient evaluations performed by the authors, not by third parties, that is, it was not a blind evaluation.

Conclusion

The high correlation between Quick-DASH score and patient satisfaction and functional outcome indicates that the Quick-DASH questionnaire is a suitable tool for evaluating adult humeral shaft fracture outcomes. Patients with a Quick-DASH score below 15 could be considered totally recovered, and patients with a Quick-DASH score above 40 could be considered not yet recovered.

Although the Quick-DASH scores obtained in this study suggest that MIPO is superior to nonsurgical treatment and other secondary outcomes suggest that all three surgical treatments are superior to nonsurgical one, the patient’s self-evaluation and return-to-work rate indicated that the functional difference is tenuous and nonsurgical treatment should not be set aside as an option for treating isolated humeral shaft fractures.

Acknowledgment

The authors acknowledged the support by the AO Trauma Latin America Board.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the AO Trauma Latin America Board.
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