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ORIGINAL PAPER

Applicability of the AAOS appropriate-use criteria for distal radius fractures in surgical practice

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Abstract
Purpose The appropriate-use criteria (AUC) for distal radius fracture (DRF) was developed by the American Academy of Orthopedic Surgeons (AAOS) to aid surgeons in making evidence-based treatment decisions for DRFs. The aim of our study was to cross-reference the management of operatively treated DRFs with the web-based AAOS published AUC recommendations.
Methods The AUC for DRF evaluates the appropriateness of ten treatment options for each of 240 mutually exclusive patient scenarios based on the combination of five factors. For every scenario, each treatment is classified as appropriate, maybe appropriate or rarely appropriate. We retrospectively reviewed the medical charts and radiographs of all adult patients ≥19 years who underwent surgery for DRFs between 1 January and 31 December 2014 and determined the rate of appropriateness of treatment in this consecutive series of patients.
Results Over the study period, 108 patients (83.3% men; mean age 39.8 years) with 113 DRFs (five bilateral) were treated surgically. The most frequent scenario was represented by a type C fracture, high-energy mechanism, normal functional demand, American Society Anesthesiologists (ASA) status 1–3 and no associated injuries. The most frequently used treatment was volar locking plate (54.0%). Based on the AUC, treatment was appropriate for 96 cases (85.0%), maybe appropriate for 15 (13.2%), and rarely appropriate for two (1.8%).
Conclusions A web-based electronic AUC application can be an attractive and easy decision-making aid for orthopaedic surgeons. Application of the AUC to clinical data was relatively simple, and most operatively treated DRFs were managed appropriately.
Level of Evidence: IV.

Keywords American Academy of Orthopedic Surgeons · Appropriate-use criteria · Distal radius fracture · Clinical practice · Operative

Introduction

Distal radius fractures (DRFs) are among the most common fractures seen by orthopaedic surgeons in the US, with an incidence of 195.2/100,000 persons per year [1]. There is a spectrum of treatment options for DRFs particularly in the adult patient population [2]. Ideally, treatment decisions should be based on high-quality literature, such as studies of level I or II evidence but are often made based on retrospective case series and clinical experience [3].

Appropriate use criteria (AUC) are an established method to assess the appropriateness of surgical procedures [4]. As part of a large effort to develop AUCs for orthopaedic procedures, the American Academy of Orthopedic Surgeons (AAOS) developed an AUC for treating DRFs that was published in March 2013 [3, 5]. The aim of the AUC was to specify when it is appropriate to use a specific procedure to improve patient care and obtain the best patient outcomes while considering the distinctions necessary in making clinical decisions. Furthermore, the AUC was established to help determine the appropriateness of clinical practice guideline

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recommendations for the heterogeneous patient population routinely seen in practice [6]. The foundation for this AUC was the clinical practice guidelines for treating distal radius fractures published in 2009 [3, 5, 7].

The AAOS AUC for DRF was developed with an accompanying mobile application that has the potential of easy incorporation into everyday clinical practice, either as an app that the surgeon can download on the phone or as a decision aid that can be integrated into the electronic medical records. With the recent development of the AAOS AUC, little has been done to validate these tools using actual patient data. To our knowledge, one prior conference abstract investigated application of the published AUC in clinical practice [8].

In this study, we cross-referenced the management of DRFs with the AUC in a large series of patients treated by general and specialised orthopaedic surgeons. We hypothesised that most cases were managed appropriately according to the AUC and that no difference would exist between upper-limb and non-upper-limb surgeons.

Materials and methods

We conducted a retrospective, institutional review board (IRB)-approved study (no. 15386/15). Between January 2014 and December 2014, 108 adult patients (≥19 years) with 113 distal radius fractures who underwent surgery were identified from the operating theatre registry. Our institution is the only level I trauma centre in Qatar, a country known for high rates of trauma. In our orthopaedic department, we have more than ten consultant surgeons who manage complex trauma that includes DRFs. Indications for surgery depend on consultant opinion, patient preference and fracture characteristics. One reviewer retrieved information regarding indications and treatments from medical charts and radiographs, and the AAOS AUC for DRF was applied to the retrieved data. This instrument was developed using the well-established RAND/University of California at Los Angeles (UCLA) Appropriateness Method [9]. This method involved a systematic review of the available literature regarding treatment of DRFs by a panel of experts in upper-extremity orthopaedic surgery and other relevant medical fields. The panel first identified five factors that were critical in surgical decision making and choice of treatment. The panel identified ten treatment options and 240 clinical scenarios that represent all possible DRF cases that might be seen in clinical practice and independently rated their appropriateness on a scale of 1–9, with three main range categories: 1–3 as appropriate, 4–6 as maybe appropriate and 7–9 as rarely appropriate. Using a modified Delphi method to determine appropriateness ratings, the AUC for DRF determined the level of appropriateness for each of the ten treatment options. The median expert rating score determined the appropriateness level for each scenario-specific treatment option and distribution of expert scores for each option determined whether there was agreement among panel members regarding the treatment score. The final appropriateness level is provided in Table 1.

The 240 scenarios were constructed based on mutually exclusive combinations of five factors: *Arbeitsgemeinschaft für Osteosynthesefragen*/Orthopaedic Trauma Association (AO/OTA) fracture type (A, B, C), mechanism of injury (high versus low energy), functional demands (homebound, independent, normal, high), American Society of Anesthesiologists (ASA) status (1–3 versus 4) and other associated injuries (median nerve injury, grade I or II open fracture, grade III open fracture, other ipsilateral injury, no associated injuries). The ten rated treatment options are:

(1) immobilisation without reduction
(2) reduction and immobilisation
(3) percutaneous pinning
(4) spanning external fixation
(5) nonspanning external fixation
(6) distraction plate
(7) volar locking plate
(8) dorsal plate
(9) fragment-specific fixation
(10) intramedullary nail. Using the free AUC web-based mobile application, we input the level of each factor and determined appropriateness and agreement levels among panel members of the ten treatments for each case in our study.

Mean and standard deviation (SD) for continuous variables and frequencies for binary and categorical variables were used to describe sample characteristics, patient scenarios and treatment options. We reported the proportion of appropriate, maybe appropriate and rarely appropriate cases. For appropriate and maybe appropriate cases, we reported the proportion of cases with agreement among the panel members who developed the AUC. For appropriate and maybe appropriate cases with no agreement, we reported the proportion of cases with alternative treatment options with agreement. We also used Fisher's exact test to determine whether treatment appropriateness was affected by whether or not the performing surgeon was an upper-limb surgeon. Statistical software (IBM SPSS version 22; SPSS Inc., Chicago, IL, USA) was used in data analysis. P value <0.05 was regarded as significant.

Results

One hundred and eight adult patients with 113 (5 bilateral) DRFs were assessed. All had ASA status 1–3 (100%) and almost all had normal functional demands (96.5%). Most were young men (mean age 39.8 years) involved in building

Table 1 Interpreting final ratings of appropriate-use criteria

Level of appropriateness	Description
Appropriate	• Median panel rating between 7 and 9 and no disagreement
Maybe appropriate	• Median panel rating between 4 and 6, or • Median panel rating 1–9 with disagreement
Rarely appropriate	• Median panel rating between 1 and 3 and no disagreement

Appropriate treatment is generally acceptable, is a reasonable approach for the indication, and is likely to improve the patients health outcomes or survival.

Maybe Appropriate treatment may be acceptable and may be a reasonable approach for the indication, but with uncertainty implying that more research and/or patient information is needed to further classify the indication.

Rarely an appropriate option for management of patients in this population due to the lack of a clear benefit/risk advantage; rarely an effective option for individual care plans; exceptions should have documentation of the clinical reasons for proceeding with this care option (i.e. procedure is not generally acceptable and is not generally reasonable for the indication).

Appropriate treatment generally acceptable, reasonable approach for indication, likely to improve patients health outcomes or survival, *Maybe appropriate* acceptable and may be a reasonable approach for indication, but uncertainty implying more research and/or patient information needed to further classify the indication, *Rarely an appropriate* due to lack of clear benefit/risk advantage; rarely an effective option for individual care plans; exceptions should have documentation of clinical reasons for proceeding (i.e. procedure is not generally acceptable and is not generally reasonable for the indication)

construction. Their functional demands were captured from medical charts. Most fractures were either type B or C (41.6% and 45.1%, respectively), with high-energy mechanism of injury (70.8%) and no associated injuries (77.8%). Patients with a type C fracture were the youngest, with a mean age of 37.4 years. Demographic and clinical characteristics of the patient cohort are provided in Table 2.

Eighteen of 240 scenarios described in AUC were observed in our patient cohort. The description and frequencies of these scenarios are provided in Table 3. The most frequent scenario was a type C fracture, high-energy mechanism, normal functional demand, ASA 1–3 and no associated injuries ($N = 34$, 30%). Four of the ten treatment options were used, with volar locking plate being the most prevalent ($N = 61$, 54.0%), followed by percutaneous pinning ($N = 37$, 32.7%), spanning external fixation ($N = 12$, 10.6%) and closed reduction and immobilisation ($N = 3$, 2.7%).

Based on the AUC, treatment was appropriate in 85.0% of cases and may be appropriate in 13.2%. Maybe appropriate cases were men with a mean age of 37.1 years and type C fractures (80%) due to high energy (73.3%) and with no associated injuries (93.3%); most were treated with closed reduction and percutaneous pinning, except for two, who were treated with spanning external fixation based on surgeon choice. Two cases were rated as rarely appropriate and were treated with closed reduction and immobilisation by non-upper-limb orthopaedic surgeons. One was elderly and sustained a femoral neck fracture after a simple fall and underwent a dynamic hip screw with closed reduction and immobilisation of the DRF in the same setting. The recommended AUC treatment was percutaneous pinning or volar locking plate. The other patient was young and sustained bilateral DRFs after falling 2 m, with one side treated with volar locking plate and the other with closed reduction and immobilisation. The recommended AUC treatment was either volar locking plate or spanning external fixation. There were no particular reasons or justifications found in the medical charts rationalising the treatment options provided to these two rarely appropriate cases.

Of appropriate cases, 79.2% had agreement among panel members who developed the AUC. There was a 20.8% agreement for appropriate and no agreement for all maybe appropriate cases. All appropriate cases with no agreement were types B and C (85.0%) DRF with a mean age of 35.8 years (95% male) and treated with either percutaneous pinning (13 of 20) or spanning external fixation (7 of 20). Recommended treatment for most appropriate cases with no agreement was volar locking plate (85.0%). Similarly, recommended treatment for all except one maybe appropriate case was volar locking plate. Appropriate with no agreement and maybe appropriate cases were predominantly young men with a mean age of 36.3 years. Proportions of appropriateness and agreement are provided in Table 4.

Fourteen percent of cases were performed by upper-limb orthopaedic surgeons. Subspecialty of the performing surgeon (upper-limb versus non-upper-limb orthopaedic surgeon) did not affect the rate of appropriateness (P value >0.05).

Discussion

Application of AAOS published AUC for DRFs and other orthopaedic conditions is an innovative concept in orthopaedic surgery. The aim of our study was to assess applicability of the AUC in a cohort of adult patients with DRF treated operatively over a period of one year. Classification of cases using the free web-based AUC mobile application was simple and easy. We found that 85.0% of cases were classified as

Table 2 Clinical characteristics of the patient cohort

Characteristics	No. (%)
Age in years (mean ± SD) [range]	40 ± 12.6 [21–69]
Sex	
Male	90 (83.3)
Female	18 (16.7)
Side of injury	
Right	49 (43.4)
Left	64 (56.6)
AO/OTA fracture type	
Type A	15 (13.3)
Type B	47 (41.6)
Type C	51 (45.1)
Mechanism of injury	
High energy	80 (70.8)
Low energy	33 (29.2)
Activity level of patient	
Normal	109 (96.5)
High functional demands	0
Independent	4 (3.5)
Home bound	0
Patient health	
ASA 1–3	113 (100)
ASA 4	0
Other injuries (in addition to DRF)	
Median nerve injury	2 (1.8)
Grade I or II open fracture	2 (1.8)
Grade III open fracture	2 (1.8)
Other Ipsilateral Injury	19 (16.8)
No associated injuries	88 (77.8)
Operated by ULS	16 (14.2)
Operated by non-ULS	97 (85.2)

SD standard deviation, *AO/OTA Arbeitsgemeinschaft für Osteosynthesefragen*/Orthopaedic Trauma Association, *DRF* distal radius fracture, *ULS* upper-limb surgeon

appropriate, 13.2% as maybe appropriate and only two cases (1.8%) as rarely appropriate. Treatment of maybe appropriate cases were based on the surgeon's decision, and no particular justification for treatment rationale for those two cases was found in the medical charts. Most appropriate with no agreement among panel members who developed the AUC and maybe appropriate cases were young males with type B and C fractures due to high energy.

There will likely never be complete or uniform agreement among orthopaedic surgeons as to the best means by which to treat a given condition, especially an injury such as a DRF, which can have many variables and management options [3, 10]. Many orthopaedic injuries and conditions are treated with experience-based rather than evidence-based medicine because high levels of evidence often do not exist [3]. In fact, 20.8% of appropriate and all maybe appropriate cases in our study had no agreement for the surgical procedure actually performeed and there was an alternative AUC-recommended treatment option with agreement. The purpose of the AUC process is to help the clinician bridge this knowledge gap and determine, in an evidence-based, easily applicable mode, the most appropriate treatment for a given condition. Hence, the AUC may provide an opportunity to improve surgical practice and reduce variation by increasing the number of appropriate cases with agreement and changing maybe appropriate to appropriate cases. Hence, a concept such as the AUC is a workable evidence-based method to minimise the use of inappropriate treatment among orthopaedic surgeons and provide the best medical care to the patient. However, for the AUC to achieve this objective, we recommend improvements. We believe the AAOS AUC should incorporate age as a factors. In our study, the patient cohort was relatively young (mean age 39.8 years) with DRFs due to high-energy trauma. This differs to patient demographics of DRF reported in the USA, for example, because the epidemiology of trauma in Qatar is very different from that in the USA. Most trauma cases in Qatar are caused mainly by falls among construction workers or motor vehicle accidents, while in the USA, most occur in elderly patients due to low-energy trauma. Treatments considered appropriate with agreement in the AAOS AUC included volar locking plate, which is appropriate in the entire adult population. However, volar locking plates may not be universally applied in young patients with type B and C fractures. Since most patients in our study sustained a type C fracture due to high-energy trauma, we expect that the majority of patients with such fractures would be treated operatively due to the nature of the fracture being completely articular. Results from the only prior study, a conference abstract, support our recommendations [8]. The authors investigated application of the AUC in a level I trauma center; only 57% of patients received treatment that matched the AUC recommendations. Their rate of appropriateness was much lower than our rate in operatively treated patients. However, when DRFs where categorised into types, 100% was achieved between actual management and AUC recommendations for type A fractures extra-articular fractures. This rate was much lower for type B and C fractures, but the exact number of each type was not reported in the abstract. Taken together, our study and the prior study suggest that incorporating age into the AUC (either as a younger versus older or different age categories) may improve the fit between patient scenarios and treatment options and thus enhance criteria ability to assist clinical decision making.

The easily accessible, downloadable and free web-based AAOS/AUC mobile application provides the orthopaedic surgeon with a handy and feasible tool to assist in the treatment decision-making process and potentially improve patient outcomes. Our findings that there was no difference in the rate of

Table 3 Description and frequency of clinical scenarios

Scenario	Activity level of patient	Mechanism of injury	AO/OTA fracture type	Other injuries	Patient health	No.	Percent
	Normal	High energy	Type A	Median nerve injury	ASA 1–3	1	(0.9)
				Other ipsilateral	ASA 1–3	1	(0.9)
				No associated injury	ASA 1–3	2	(1.8)
			Type B	Grade I or II open fracture	ASA 1–3	1	(0.9)
				Other ipsilateral injury	ASA 1–3	9	(8.0)
				No associated injuries	ASA 1–3	20	(17.7)
			Type C	Median nerve injury	ASA 1–3	1	(0.9)
				Grade I or II open fracture	ASA 1–3	1	(0.9)
				Grade III open fracture	ASA 1–3	2	(1.8)
				Other ipsilateral injury	ASA 1–3	7	(6.2)
				No associated injuries	ASA 1–3	34	(30.0)
		Low energy	Type A	No associated injuries	ASA 1–3	10	(8.8)
			Type B	Other ipsilateral injury	ASA 1–3	2	(1.8)
				No associated injuries	ASA 1–3	12	(10.6)
			Type C	No associated injuries	ASA 1–3	6	(5.3)
	Independent	High energy	Type B	No associated injuries	ASA 1–3	1	(0.9)
			Type A	No associated injuries	ASA 1–3	1	(0.9)
		Low energy	Type B	No associated injuries	ASA 1–3	2	(1.8)

ASA American Society of Anesthesiologists

appropriateness between upper- and non-upper-limb surgeons can possibly be explained by the fact that DRFs are one of the most common injuries dealt with by most orthopaedic surgeons. Hence, it can be suggested that the AUC is equally beneficial to all orthopaedic surgeons who treat such injury, regardless of their subspecialties.

Our study has several limitations. Firstly, there were only 18 clinical scenarios observed of 240 described in the AUC. While this may indicate a nonrepresentative sample at first glance, it is typical when applying criteria that only a small number of patient scenarios will represent most patients presenting to surgeons in clinical practice. This has been observed in other, similar, studies when applying AUC to actual data [4, 11–14]. For example, Ibrahim et al. [12] reported eight scenarios of the 220 described in the AUC for paediatric humerus supracondylar fractures in 94 patients. Secondly, we applied the AUC to operatively treated DRFs because this was a retrospective study and we were unable to include cases treated non-operatively as there is no reliable system at our institution to accurately capture data on these fractures accurately. This limits our conclusion regarding applicability of AUC to all types of DRFs. Finally, our study was based on a retrospective review of medical charts and radiographs by one reviewer, with no patient outcomes. This makes our study unable to validate the use of the AUC for treating DRFs in clinical practice. However, as a first step in this validation process, our study assesses whether there are problems with collecting and interpreting the AUC in surgical practice. Another recent study highlighted problems with similar criteria [12]. At present, using the AAOS/AUC for DRFs is limited. Therefore, considerably more work is necessary to determine its validity using patient outcomes to increase the use of this accessible and potentially helpful tool.

Table 4 Rates of appropriateness and agreement

AUC appropriateness and agreement rates	No. (%)
Appropriate	96 (85)
Subclassification of appropriate cases	
With agreement	76 (79.2)
No agreement, alternative had agreement	20 (20.8)
Maybe appropriate	15 (13.2)
Subclassification of maybe appropriate cases	
With agreement	0 (0)
No agreement, alternative had agreement	15 (100)
Rarely appropriate	2 (1.8)
Subclassification of rarely appropriate cases	
With agreement	1 (50)
No agreement, alternative had agreement	1 (50)

In conclusion, most DRFs treated operatively in our study were managed appropriately while adhering to the AUC recommendations. However, it is recommended that further research be undertaken to validate the tool and evaluate patient outcomes in different clinical settings. We also suggest that patient age be incorporated in the AUC and that further studies be performed to assess its appropriateness for operative and nonoperative treatment of DRFs.

Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

For this type of study, formal consent is not required.

Conflict of interest Nil

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