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Gaps and Opportunities in Various Aspects and Treatment/Management of Distal Radius Fractures

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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Opinion Article

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ABSTRACT

Distal radius fractures (DRFs) are the most common type of fracture presented in hospitals, clinics, orthopaedic centers, and trauma practices all over the world. Thus, there is a very large body of literature on the many aspects of DRFs, particularly, nonsurgical and surgical treatment/management modalities. The present contribution has two focus areas. The first is a summary of many aspects of DRF on which there is controversy or inadequate coverage. As a consequence of this summary, the second focus is detailed expositions on opportunities for future work in nine areas. Results from some of this future work may aid selection of treatment/management modality for a specified patient-fracture pattern combination; for example, detailed cost-utility analyses of candidate modalities. Results from other future studies may translate to improved patient outcomes; for example, further studies on the photodynamic bone stabilization system for intramedullary fixation of fractures.

Keywords: Distal radius fractures; treatment modalities; clinical studies.

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1. INTRODUCTION

Broadly speaking, aspects of distal radius fractures (DRFs) covered in the literature may be grouped into three categories. In the first category are studies of aspects on which there is widespread agreement. Three such aspects are recognized. The first is etiology, with the preponderance of DRFs being the result of either low-energy incidents, such as using an outstretched hand to break a fall from a slippery floor or a road pavement, or high-energy trauma, such as falling from a height > 1 m in a bicycle, ski, or motor vehicle accident [1-8]. The second is incidence, with DRFs being the most common fracture cases seen in emergency rooms, trauma centers, and general orthopaedic practices [9-11]. Furthermore, there is a sizeable number of cases of distal radius fragility fractures, which occasionally present in severely osteoporotic patients [12]. The third comprises the most common complications, examples being damage to the median nerve, neuritis, and marked depreciation in many hand functions, such as grip strength and range of motion [4,13]. In the second category are studies of aspects on which there is much controversy, such as fracture classification schemes for complicated cases (such as comminuted fractures), reliability of a given scheme, and the most appropriate treatment/management modality for a given combination of patient and fracture pattern [14,15]. In the third category are studies on aspects that have received little attention, such as detailed epidemiological studies, prediction of clinical outcome for a given combination of facture pattern and treatment method, analysis of failed/fractured plating systems [16], and cost determinations for various treatment options.

The present contribution, which focuses on various aspects in the second and third categories, is organized into three parts. In the first part, key features of studies on these aspects are highlighted, with a view to pointing out gaps/shortcomings of the literature. Having done that, the second part contains expositions on salient features of opportunities for future work that will address some of the gaps/shortcomings. The criterion used to select an opportunity area for inclusion is that results from work in it have high potential to produce results that may contribute to improved patient outcomes. A summary of the key points made in the present contribution is given in the third part.

2. GAPS AND SHORTCOMINGS

There is lack of consensus on the temporal change in incidence of DRFs. For example, 1) in the United States, in one study, the estimated frequency of claims per annum for treatment of DRFs in Medicare patients, over the period 1996-2005, was more or less steady, at 81,005 ± 4,028 cases [17], but, in another study, the incidence was reported as increasing [18], whereas 2) in Taiwan, incidence increased consistently; for example, by about 40% over the period 2000-2007 [19]. There are very limited data on epidemiology with respect to aspects such as racial and ethnic groups in countries such as the United States and United Kingdom [20].

There is a large collection of standard radiograph (SR)-based schemes for classifying DRF patterns, examples being the AO, Barton, Barzulla, Chauffeur, Colles, Cooney, Fernandez, Frykman, Galeazzi, Mader and Penning, Mayo, Melone, Older, and Smith schemes [21,22]. Reliability (measured using inter- and intra-observer agreement among a group of clinical assessors, such as hand surgeons or wrist surgeons or orthopaedic surgeons) of some of these schemes is acceptable (for example, AO [23]), but, for others, it is poor (for example, Fernandez [24]). Furthermore, low reliability measures between various classification schemes, for a given fracture pattern in adults, such as displaced type, highlight their insufficiency [25,26]. Classification of comminuted fractures and other complicated cases requires higher visualization than is provided in SRs; as such, in these situations, conventional computed tomography (CT), SR in combination with CT, cone-beam CT, or magnetic resonance imaging is used [27-29]. However, with regard to these alternative imaging methods, 1) the only classification scheme presented is a CT-based one in the case of comminuted intra-articular fractures, with five distinct types being identified [30]; and 2) there is limited information on the reliability of the radiological measurements [27,29].

There are a host of prospective randomized controlled trials (RCTs) of either a given treatment/management method or comparison of two or more methods in various patient populations (Table 1). Two shortcomings of this body of literature are that 1) the preponderance of the studies were carried out in only one center, and 2) very few studies involved patients who are osteoporotic or Type II diabetic, even though, in every country, there is a steep rise in the number of people in these two demographic sub-groups with time [50-52].

There is also a large body of literature on a new generation of treatment/management methods, examples being 1) plating systems involving new materials and/or new designs, such as variable-angle volar locking plate [32,33], a carbon fiber-reinforced poly (etheretherketone) (PEEK) volar plate [53], and a bioresorbable dorsal locking plate [54]; 2) intramedullary fixation (IM) devices, such as a non-bridging cross-pin fixator [55], the MICRONAIL® device (Wright Medical Technology, Arlington, TN, USA) [56], the DRS System (Conventus Orthopedics, Maple Grove, MN, USA), the WRx Wrist Pin (Sonoma Orthopedic Products, Inc., Santa Rosa, CA, USA), the photodynamic bone stabilization system (PBSS) (IlluminOss®; IlluminOss Medical, Inc., East Providence, RI, USA) [57]), and a threaded, cannulated pin (T-Pin; Union Surgical LLC, Philadelphia, PA, USA) [58]; 3) hybrid plating and IM devices, such as the Dorsal Nail Plate® (Hand Innovations LLC, Miami, FL, USA) [56]; and 4) local administration of recombinant human platelet-derived growth factor [59]. However, there are very few reports of comparative clinical studies involving a new method and an established method, for the same patient population [60] and, most importantly, none of these studies was a prospective RCT, with long follow-up (at least two years).

There are only a few studies in which patient factors at initial presentation of the fracture that reliably predict radiographic outcomes and/or functional outcomes of a given management modality have been identified. Examples of such factors are older age [61], extensive metaphyseal comminution [62], positive ulnar variance [61, 62], local bone mineral density or osteoporosis status [63,64], presence of volar comminution [61], high radius height [65], presence of peripheral neuritis [66], and type of joint fragment [67]. There are even fewer studies in which predictions were compared to results obtained from application of actual management practice in the treatment of a specified fracture type or in which recommended criteria for using a particular treatment modality are compared to actual treatment method(s) used [68].

Table 1. Summary of some features of a sample of prospective, randomized, controlled trials of treatment/management modalities of distal radius fractures

Authors [Ref. #]	Treatment groups	Type of study[a]
Brogren et al. [31]	Cast	Single-center; individual
Couzens et al. [32]	Fixed-angle volar plating	Single-center; individual
Fowler and Ilyas [33]	Variable-angle volar plating	Single-center; individual
Jakob et al. [34]	Double plating	Single-center; individual
Miller et al. [35]	Cast vs. percutaneous pinning	Single-center; comparison
Boutis et al. [36]	Cast vs. prefabricated splint	Single-center; comparison
Grewal et al. [37]	Percutaneous pinning vs. open reduction and internal fixation	Single-center; comparison
Roh et al. [38]	External fixation vs. volar plating	Single-center; comparison
Williksen et al. [39]	External fixation with adjunct pin vs. volar plating	Single-center; comparison
Plate et al. [40]	Intramedullary nailing vs. volar plating	Single-center; comparison
McFadyen et al. [41]	K-wires vs. volar plating	Two centers; comparison
Wang et al. [8]	External fixation vs. open reduction and internal fixation	Meta-analysis
Cui et al. [42]	External fixation vs. internal fixation	Meta-analysis
Margaliot et al. [43]	External fixation vs. volar plating	Meta-analysis
Walenkamp et al. [44]	External fixation vs. volar plating	Meta-analysis
Zhang et al. [45]	External fixation vs. volar plating	Meta-analysis
Kasapinova et al. [46]	External fixation and/or K-wires vs. open reduction and plate fixation	Meta-analysis
Wei et al. [47]	Dorsal plating vs. volar plating	Meta-analysis
Chaudhry et al. [48]	K-wires vs. volar plating	Meta-analysis
Zong et al. [49]	K-wires vs. volar plating	Meta-analysis

[a]*Individual: Only one modality was used in the study; comparison: two or more modalities were used in the study*

Although guidelines have been proposed for making a decision on choice of treatment modality for a given fracture pattern [69,70], strictly speaking, observations regarding shortcomings of the literature, as described above, mean that there is no evidence-based reason for recommending one modality over others. Indeed, in most cases, the choice is, simply, surgeon preference [71-73]. Furthermore, even though a plethora of outcome measures, such as VAS score, QuickDASH score, and range of motion, are routinely obtained in the post-treatment period [34,39,41], very little has been reported on the efficacy of a given treatment for a given fracture pattern by, for example, calculating the minimum clinically important difference in an outcome measure prior to and following treatment [74].

There are only a few reports of failure/fracture of fixation devices used in surgical treatment, these being on locking plates [75,76] and a cross-pin fixator [77], and even fewer ones that include analysis of these failures/fractures [76].

The true economic burden of DRFs is unclear because of three reasons. First, only few studies have been published on this aspect [73,78-83]. Thus, 1) in 1997, it was estimated that the mean cost for treating a patient > 60 years old was ~$500 [80]; 2) over the period 2005-2008, the mean cost per patient treated using volar plating in a major academic medical center's inpatient hospital was $7,640 versus $5,220 in a hospital-owned ambulatory stand-alone surgery center in the same city [73]; 3) in a 2010 study in Spain, the mean treatment cost and mean cost for disability days when a conservative treatment (cast) was used were $1,075 and $16,004, respectively, whereas when a surgical treatment was used (angular stability plating), the corresponding costs were $9,850 and $8,462 [79]; and 4) in 2007, the United States Medicare agency made payments of about $250 million to cover costs for treating DRFs and patient physical rehabilitation following treatment [81]. The second reason is that among the aforementioned studies, there are differences on a number of important aspects, notably, items included in the cost analysis. For example, in the study by Shyamalan et al. [78]), only the costs of the devices (Kirschner wires and volar locking plate system) were considered but Guiterrez and Velazquez [79] included cost of bed-days, surgery, implant, cast, doctor visits, disability-days, and rehabilitation. The third reason is that with very few exceptions, the calculated patient cost obtained in a given study is not normalized. One such exception is the report on patients treated in one of 18 trauma centers in the United Kingdom, in which the mean cost was normalized with respect to the quality-adjusted life-year of a patient (QALYP); the normalized costs were $7,077 and $8,435 when the treatment modalities were external fixation (with percutaneous Kirschner wires) and a fixed-angle volar locking plating system, respectively [83].

3. OPPORTUNITIES

The gaps/shortcomings of the extant literature, as highlighted in the preceding Section, suggest several opportunities for future work. Key features of nine such opportunity areas are presented here.

The first is study of aspects of the extent of DRFs in various racial and ethnic groups, within a given country where there are many such groups, such as the United Kingdom and the United States. Such aspects include incidence and its change with time and outcomes of a given treatment modality for a specified fracture pattern. This body of information could inform and guide treatment choice for patients in a specified racial or ethnic group.

The second is systematic study on whether or not, ultimately, the scheme used to classify fracture pattern matters. This study could take the form of investigating the influence of the classification scheme used to characterize a specified fracture pattern on treatment modality chosen and patient outcomes.

Work in the third opportunity area is development of a consensus document in which minimum values for all clinically-relevant properties of materials for use in a specified surgical treatment modality, such as IM device or a plating system, are stated. Then, each new material, such as a new bone cement formulation [84-86] for use as supplementation of volar locking plating in treatment of unstable fracture in the osteoporotic patient or a new injectable monomer for the PBSS, would be assessed relative to these minimum property values. This methodology would result in shortening of the time cycle in the development (and, ultimately, clinical evaluation) of new devices and systems.

The focus of work in the fourth opportunity area is one of the emerging surgical treatment methods; consider, for example, the PBSS. The PBSS was only recently introduced to the clinical community [57]; thus, the basic principles are outlined here: use a flexible cannulated drill to create a canal in the fractured bone, insert a balloon that contains a light-conducting fiber into the canal, use a standard syringe to fill the balloon with a liquid monomer (thereby causing the balloon to conform to the contours of the medullary canal at the fracture site), and, then, use a visible-light system (wavelength = 436 nm) to convert the liquid monomer to a hard polymer. Two sets of studies are envisaged in this opportunity area. First, research studies on innovative methods of creating the canal, and, second, clinical studies to determine the influence of the size of the reamed canal on functional and clinical outcomes for a specified fracture type.

The fifth opportunity area is systematic study of patient factors at initial presentation that reliably predict functional outcomes (such as grip strength, range of motion, and DASH score) and radiological outcomes (such as radial length, ulnar variance, and volar tilt) for a given combination of fracture type and management modality, especially widely-used ones such as the fixed-angle volar plating system.

The sixth opportunity area is performance of further studies on the extent to which recommended criteria for treating a specified fracture type, such as the AAOS Appropriate Use Criteria [68,69], are utilized in clinical practice. In this exercise, data should be collected from low-, medium-, and high-volume clinical practices in a large number of countries over a long period of time (at least 7 years). Results from this analysis could then be used to modify the recommended criteria.

The seventh opportunity area is cost-effectiveness/cost-utility analysis, an issue that is particularly topical and important as value-based health care delivery is now being demanded in nearly country in the world [87]. For this purpose, the first step should be detailed calculation of the full direct cost (FDC) of treating patients who present with a specified fracture pattern. FDC should include, for example, cost of surgery and cost of utilities for the hospital/clinic. In the second step, FDC should be normalized (for example, using QALYP [83]). This normalized FDC should be obtained for each of the widely-used treatment modalities. Such information could then be used by, for example, insurance companies in the United States for decision on coverage of cost of a modality.

The eighth opportunity area is establishment of a consensus for the minimum clinically important difference (MCID) in a given outcome measure for a specific combination of fracture pattern and treatment modality, such as DASH score and grip strength. MCID could then be used as evidence of the efficacy of that modality. Work in this field should involve large numbers of patients and clinical centers over a long period of time.

The ninth opportunity area is detailed analysis of *in situ* fractures of widely-used surgical devices, notably, fixed-angle volar plating systems, utilizing a panoply of available tools, such as optical microscopy, scanning electron microscopy, energy dispersive x-ray analysis, atomic force microscopy, x-ray photoelectron spectroscopy, and CT. Results of these analyses would contribute to improved designs of these devices.

One final word: Clinical studies feature in many of the opportunity areas, and, ideally, these should be Level I therapeutic studies. However, constraints of time and cost mean that, realistically, in the first instance, studies with a lower level of evidence (for example, Level III therapeutic studies) [88] may be carried out.

4. SUMMARY

Gaps and shortcomings of the literature on various aspects and treatment/management of distal radius fractures include inadequate information on the incidence in various ethnic groups within a given country and, hence, absence of targeted treatment modalities; a proliferation of fracture pattern classification schemes, many of which have poor reliability and repeatability; and very limited number of prospective randomized controlled trials in which a well-known treatment method is compared to a new method. The above observations suggest opportunities for future work in a number of areas in this field, with some features of nine such areas being presented.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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