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The association between patient education level and economic status on outcomes following surgical management of (fracture) non-union

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ABSTRACT

Background: Socioeconomic disparities are an inherent and currently unavoidable aspect of medicine. Knowledge of these disparities is an essential component towards medical decision making, particularly among an increasingly diverse population. While healthcare disparities have been elucidated in a wide variety of orthopaedic conditions and management options, they have not been established among patients who present for treatment of an ununited fracture. The purpose of this study is to answer the following questions: 1) Following surgical management of (fracture) non-unions, are there differences in outcomes between differing ethnic groups? 2) Following surgical management of (fracture) non-unions, are there differences in outcomes between patients with differing education levels? 3) Following surgical management of (fracture) non-unions, are there differences in outcome between patients with differing incomes?

Methods: Between September 2004 and December 2017, operatively treated patients who presented with a long bone fracture non-union were prospectively followed. These patients presented with a variety of fracture non-unions that underwent surgical intervention. Sociodemographic factors were recorded at presentation. Long-term outcomes were evaluated using the Short Musculoskeletal Function Assessment (SMFA), pain scores, post-operative complications and physical exam at latest follow up. The SMFA is a 46-item questionnaire, assessing patient functional and emotional response to musculoskeletal ailments.

Results: Three-hundred-twenty-nine patients met inclusion criteria. Patients with a lower education had worse long-term functional outcomes ($P < 0.001$) and increased pain scores ($P = 0.002$) at latest follow-up. Patients who made less than $50,000 annually had worse long-term functional outcomes ($P = 0.002$) and reported higher pain scores ($P = 0.003$) following surgical management of (fracture) non-unions. Multiple linear regression demonstrated education level to be an independent predictor of long-term functional outcomes following surgical management of (fracture) non-unions (B= -0.154, 95% Confidence Interval [CI]=-10.96 to -1.26, $P = 0.014$). No differences existed in outcomes or pain scores between those of different ethnic groups. No differences existed regarding post-operative complications and time to union between patients of different ethnic groups, educational levels and income status.

Conclusion: Patients with lower education levels and individuals who make less than $50,000 annually have worse functional outcomes following surgical management of (fracture) non-unions. Orthopaedic trauma surgeons should therefore be aware of these disparities, and consider early interventions aimed at optimizing patient recovery in these subsets.

Introduction

Fractures are a common occurrence in the United States. Nearly half of all Americans will sustain a fracture by the time they are sixty-five years old [1]. Following a fracture, a non-union may occur [2]. A fracture is considered to be ununited if there is no progression in radiographic and clinical healing over a 3-month time frame [2]. There are numerous risk factors that may increase the chance of developing a fracture non-union, such as decreased bone vascularity, bone loss, excessive motion of the fracture site and infection [2]. Patients who develop a fracture non-union usually experience increased pain and decreased function, which may cause disability and decreased quality of life [2–5]. Furthermore, these patients may suffer from significant emotional distress4]. Fracture non-unions contribute to an economic burden on society, health care and patients. Additionally, non-union

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treatment is a costly burden to the health care system. Much has been established regarding treatment of non-unions, yet a diminutive amount of information is known in regards to the effects of socioeconomic and educational factors on outcomes following surgical management of (fracture) non-unions [2–5,6]. It is imperative we understand if disparities affect outcomes following surgical management of (fracture) non-unions, as this injury may be a root of significant disability6,7].

Socioeconomic status has been identified as a major risk factor for poor health outcomes [8–30]. Literature has demonstrated that patients with lower socioeconomic backgrounds experience more medical ailments than those with higher socioeconomic status, as access to healthcare is often limited in the former [22]. Recent studies have focused on the role ethnicity plays in outcomes following orthopaedic surgery [8–20]. African-American adults have been demonstrated to have worse functional outcomes following joint arthroplasty in comparison to Caucasian adults [13–15]. Minorities have also been reported to have worse long-term outcomes following orthopaedic trauma [18,20].

Ethnic disparities in outcomes following orthopaedic surgery is likely multifactorial, as income, education, access to medicine, and health literacy are all likely to play a role [18,22]. Numerous studies have demonstrated that patients who did not receive a college education have worse outcomes following various orthopaedic surgical procedures [18,22–26]. The purpose of this study is to answer the following questions: 1) Following surgical management of (fracture) non-unions, are there differences in outcomes between differing ethnic groups? 2) Following surgical management of (fracture) non-unions, are there differences in outcomes between patients with differing education levels? 3) Following surgical management of (fracture) non-unions, are there differences in outcome between patients with differing incomes?

Methods

Between September 2004 and December 2017, patients who received operative treatment for a long-bone fracture non-union, at a single academic institution, were enrolled in a prospective research registry that received institutional review board (IRB) approval. The non-union repair was performed by one of three fellowship trained orthopaedic traumatologists at a large urban academic center. The academic institution in which this study was performed, consists of two level 1 trauma centers and a tertiary care hospital. We serve a population of several million, admitting over 4000 trauma patients per year, of which approximately 1600 are orthopaedic trauma patients. The tertiary care hospital performs over 20,000 orthopaedic surgeries a year. Of these orthopaedic procedures, approximately 1000 per year are fracture cases. Furthermore, the senior author has a large trauma reconstruction referral practice that services a population area of about 10,000,000.

All fracture nonunions were classified with plain radiographs (Figs. 1 and 2) using the system of Weber and Cech [31]. Computed tomography (CT) scans were obtained to confirm a non-union if the diagnosis was not clear from standard radiographs and physical examination. Baseline laboratory tests were obtained when deemed appropriate (in the case of previous surgery) and included the following: erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) and leukocyte count. If the surgeons suspected an infection, a labeled nuclear study or an MRI study was performed.

All patients underwent non-union repair using a standardized protocol. Patients not suspected of having an infection underwent open debridement of the non-union site with reduction and internal fixation (ORIF) or in some cases closed treatment with use of a reamed exchange nailing. Furthermore, if an infection was confirmed pre-operatively, patients were treated by either application of a multiplanar external fixator definitively, or with a temporary fixator (utilizing a staged protocol) until the infection resolved, in which definitive internal fixation was then performed. Finally, bone grafting was employed at the discretion of the treating surgeon (autogenous iliac crest or iliac crest aspirate with adjunct bone morphogenic protein and an appropriate carrier).

Fig. 1. Example of an upper extremity nonunion. AP Radiograph demonstrating an atrophic (fracture) non-union of the mid humerus shaft.

Intraoperative cultures were collected in the case of a revision procedure. If bacterial organism was present, antibiotic therapy was guided by culture results and infectious disease recommendations. Patients with positive cultures were treated with antibiotics for 6-weeks post-operatively. The treating surgeon along with an infectious disease specialist closely followed the patients who were diagnosed with an infected non-union. Subsequent laboratory tests of ESR and CRP were collected to track the infection's response to antibiotic treatment.

At initial enrollment, demographics and socioeconomic status (age, ethnicity, gender, level of education, income, occupation) along with a preoperative baseline Short Musculoskeletal Function Assessment (SMFA) and VAS pain scores were obtained. Initial injury characteristics were collected: anatomic site of fracture, soft tissue injury (history of open fracture or compartment syndrome), nerve injury, vascular injury, orthopaedic polytrauma, mechanism of injury, previous surgeries, history of infection, and non-union type (atrophic, oligotrophic, hypertrophic). Previous surgical details and medical history were obtained utilizing the electronic medical record and pre-operative SF-36 and SMFA surveys to assess baseline function. The Charlson comorbidity index (CCI) was collected for each patient. Physical examination focused on the affected extremity. The soft tissue envelope was examined for integrity. The suspected non-union site was evaluated for gross motion and areas of tenderness.

Fig. 2. Example of a Lower extremity nonunion. AP Radiograph demonstrating an atrophic (fracture) non-union of an atypical femur fracture.

Post-operative functional outcomes were measured by the SMFA and pain scores were recorded using the Visual Analog Scale (VAS). Functional outcomes were recorded at 3-month, 6-month, and long-term (minimum of 12-month) follow up. Achievement of clinical and radiographic union and post-operative complications were recorded at each follow-up as well. Nonunion healing was determined by the attending surgeon based upon clinical exams and radiological parameters of union. Union was diagnosed when bridging of three or four cortices were present, pain had resolved and motion at the site was absent [2]. CT scans were obtained at follow-up if plain radiographs were deemed unequivocal. This study consisted of a chart, radiographic and functional outcome review of prospectively collected data.

Patients were included in this study if they had a minimum postoperative follow up of 12-months, provided their income status and educational level, and complete data at all follow up visits.

For the purpose of this study, patients were divided into groups based on their ethnicity, educational level and income status. Ethnicity consisted of Caucasian, African-American, Hispanic, or 'Other' ethnic status. Education level was divided into two groups. The lower educational level group consisted of individuals who had received either a high-school education or a general education diploma (GED), and those who did not complete high school. The "higher" educational level group consisted of individuals who received some form of college education, were college graduates and those who went on to receive a post-baccalaureate degree. Income status was also divided into two groups based on yearly income, above (higher income status) or below (lower income status) $50,000 annually.

Statistics were calculated using IBM SPSS version 23 (Armonk, NY: IBM Corp.). Statistical analysis was used to assess if ethnic groups, income status, or education level influenced long-term functional outcomes, pain scores, time to healing, and post-operative complications following surgical management of (fracture) non-unions. For all analyses, significance was set at $P < 0.05$ levels. Student's t-tests were used to assess differences between continuous variables. Multiple linear regression was performed with the total standardized SMFA being the dependent variable, while demographics and patient reported factors (age, gender, ethnicity, income status, educational level, tobacco use, comorbidity of diabetes), initial injury information (open vs. closed fracture, compartment syndrome, orthopaedic polytrauma, high-energy vs. low-energy mechanism, arterial injury, nerve injury), and non-union characteristics (surgical index, fracture location, non-union type, infected non-union, time from original fracture to non-union surgery) were independent variables. A chi-square analysis was performed to rule out any inherent significant associations between demographics or injury details and study variables.

Results

329 patients met the inclusion criteria. It should be noted that 75% of patients in this set received initial care at an outside institution, while 25% of the cohort were initially treated at our center. In regards to socioeconomic measures, the majority of patients were of Caucasian ethnicity (200, (60.8%)), high-education level (179, (55.4%)), and lower income status (207, (62.9%)). Complete demographics and patient reported factors are displayed in Table 1, while study variables of eligible patients are displayed in Table 2. There were no differences between study groups regarding fracture type, or comorbidity status. Initial injury characteristics are demonstrated in Table 3. 229 injuries (69.6%) requiring surgical management of the (fracture) non-union, were of the lower extremity. 217 non-unions (66%) underwent plate and screw fixation, 48 (14.6%) underwent exchange nailing, 8 (2.4%) underwent dynamization and 33 (10%) underwent external fixation. Complete characteristics of the fracture non-union included in this

Table 1
Demographics of eligible patients.

Characteristic		p-value of association with ethnicity	p-value of association with education level	p-value of association with income status
Number of Eligible Patients: N	329			
Mean age at time of non-union repair (years)	48.3 years	.642	.586	.481
Gender: N, (%)				
Male	182, (55.3%)	.318	.294	.408
Female	147, (45.7%)			
Tobacco Use: N, (%)	65, (19.8%)	.164	.134	.203
Diabetes: N, (%)	51, (15.5%)	.179	.264	.197

Table 2
Study variable demographics and association analysis.

Characteristic	Category	Number of patients N, (%)	p-value of fracture type association	p-value of comorbidity (CCI) association
Ethnicity			.637	
	Caucasian	200, (60.8%)		
	African-American	36, (10.9%)		.387
	Hispanic	63, (19.1%)		
	Other	30, (8.1%)		
Education level				
	Low education level	150, (45.6%)	.767	.479
	High education level	179, (55.4%)		
Annual income status				
	Less than $50,000	207, (62.9%)	.684	.401
	More than $50,000	122, (37.1%)		

Table 3
Initial injury characteristics.

Characteristic N, (%)	N, (%)
Orthopaedic polytrauma	72, (21.9%)
Compartment syndrome	7, (2.1%)
Open fracture	97, (29.5%)
Nerve injury	29, (8.8%)
Vascular injury	33, (10.0%)
Mechanism of injury	
High-velocity	192, (58.4%)
Low-velocity	137, (41.6%)

Table 4
Non-union characteristics.

Characteristic		p-value of association with ethnicity	p-value of association with education level	p-value of association with income status
Fracture Location: N, (%)				
Tibia/fibula	133, (40.4%)	.637	.767	.684
Femur	88, (26.7%)			
Humerus	59, (17.9%)			
Forearm	20, (6.1%)			
Clavicle	20, (6.1%)			
Foot	5, (1.5%)			
Pelvis	3, (0.9%)			
Scapula	1, (0.03%)			
Required a flap: N, (%)	18, (5.5%)	.912	.874	.768
Non-union type: N, (%)				
Atrophic	193, (58.7%)			
Hypertrophic	69, (21.0%)	.798	.679	.581
Oligotrophic	67, (20.3%)			
Infectious Etiology: N, (%)	64, (19.5%)	.304	.361	.405
Time from original fracture to non-union repair (months)	12.92 months	.812	.842	.207

analysis are demonstrated in Table 4. Neither demographic details nor any injury/non-union details differed between study groups, including age, gender, tobacco use, diabetes status, open fracture status, complication profile, original mechanism of injury, non-union type, time from original fracture to repair, infection status, nor requirement for a flap in repair.

Functional outcomes

At 3-month follow-up, no differences were noted in functional outcomes between ethnic groups (P = 0.086) and income status (P = 0.197). At 3-month follow-up, patients who had a lower educational level had worse functional outcomes, compared to patients who had a higher educational level, by a mean difference in SMFA score of 5.3 (P = 0.033). Lower educational level was not an independent predictor of worse functional outcomes, at the 3-month time point, as demonstrated by a multiple linear regression (P = 0.289).

At 6-month follow-up, no differences were noted in functional outcomes between ethnic groups (P = 0.346). At 6-month follow-up, patients who had a lower income status, had worse functional outcomes, compared to patients who had a higher income status, by a mean difference in SMFA score of 6.6 (P = 0.005). At 6-month follow-up, patients who had a lower educational level had worse functional outcomes, compared to patients who had a higher educational level, by a mean difference in SMFA score of 7.9 (P < 0.001). Lower income status was not an independent predictor of worse functional outcomes, at the 6-month time point, as demonstrated by a multiple linear regression (P = 0.558). Lower educational level was not an independent predictor of worse functional outcomes, at the 6-month time point, as demonstrated by a multiple linear regression (P = 0.176).

At long-term follow-up (mean of 25.4 months (range 12 months to 120 months)), no differences were noted in functional outcomes between ethnic groups (P = 0.793). Long-term functional outcomes were worse in patients who had a lower income status, compared to patients who had a higher income status, by a mean difference in SMFA score of 6.9 (P = 0.002). Patients who had a lower educational level had worse functional outcomes at long-term follow-up,

compared to patients who had a higher level of education, by a mean difference of 9.3, in regards to total SMFA score (P < 0.001). Significant differences in long-term functional outcomes between education and income levels are demonstrated in Table 5. Multiple linear regression demonstrated that a lower education level is an independent predictor of worse functional outcomes, following surgical management of (fracture) non-unions, at long-term follow-up (*B*=-0.154, 95% Confidence Interval [CI]=-10.96 to -1.26, P = 0.014).

Pain scores

At 3-month follow-up, no differences were noted in reported pain scores between ethnic groups (P = 0.679), educational groups (P = 0.402) or income groups (P = 0.647). At 6-month follow-up, no significant differences were noted in reported pain scores between ethnic groups (P = 0.183). At 6-month follow-up, patients who had a lower income status had higher pain scores, by a mean of 0.7, compared to patients who had a higher income status (P = 0.041). At 6-month follow-up, patients who had a lower educational level had higher pain scores, by a mean of 0.8, compared to patients who had a higher educational level (P = 0.026). At long-term follow-up, no significant differences were noted in reported pain scores between ethnic groups (P = 0.288). Reported pain was higher in patients who had a lower income status, by a mean of 0.9, compared to patients who had a higher annual income (P = 0.003). Patients who had a lower educational level also had higher pain scores at long-term follow-up, by a mean of 0.9, compared to patients who had a higher level of education (P = 0.002) (Table 5).

Time to union and complications

No differences existed in time to union existed between ethnic groups (P = 0.812), educational groups (P = 0.842) or income groups (P = 0.207). No differences existed in post-operative complications between ethnic groups (P = 0.429), educational groups (P = 0.514) or income groups (P = 0.611).

Discussion

An abundance of orthopaedic research in recent decades has led to improved management of fractures, yet patients are still burdened by post-traumatic complications such as a fracture non-union. Progress has been made in regards to understanding and treating long-bone non-unions. Studies, which provide long-term follow-up, have focused on how surgical techniques affect outcomes following surgical management of (fracture) non-unions [3–6]. Orthopaedic surgeons' are generally concerned with achieving union following acute fractures and in post-traumatic repairs. This is an appropriate focus, as Egol et al. demonstrated an association between non-union healing and improved long-term functional outcomes [2]. However, we have come to recognize that outcomes following orthopaedic trauma may be influenced by ethnicity, socioeconomic and educational disparities [18,20,27].

This report demonstrates that patients with a lower education level reported poorer outcomes at 3-month, 6-month and long-term follow-ups, compared to those with similar injuries who received higher education. Additional economic disparities also seem to exist, as patients making less than $50,000 a year had worse outcomes compared to similar patients who had reported earning greater than $50,000 on an annual basis. These groups of patients however are not subject to differences in time to union and post-operative events. Our study is comparable to numerous reports, which demonstrate worse outcomes in orthopaedic patients of lower socioeconomic status and decreased education levels [21–30]. Paksima et al. reported similar results when looking at disparities following distal radius fractures. Patients from a lower socioeconomic class and those with decreased education reported higher pain scores, decreased range of motion, and worse functional outcomes [30]. Feldman et al. demonstrated that patients with decreased levels of education experienced worse outcomes following total knee arthroplasty [23]. In a similar fashion, Greene et al. found patients with a lower educational level to have increased pain and worse function following total hip arthroplasty [24].

Several hypotheses exist to explain these findings. Higher socioeconomic status bestows greater access to medical care, healthier lifestyle habits, and decreased morbidity and mortality [28,29]. It has been demonstrated that patients who come from a higher socioeconomic area and who have higher education levels, report better emotional well-being, which in turn contributes to improved physical health and function [32–34]. A decreased education level may also lead to inadequate health literacy. Patients with low health literacy lack the skills to understand basic health information related to their illness. Adequate health literacy is a necessity for optimal function following diagnosis and treatment of physical and mental ailments [35,36]. In addition to suboptimal outcomes, patients with decreased health literacy are more likely to require increased hospitalizations when burdened with an illness [37,38]. Individuals with poor health literacy and minimal education have been demonstrated to have unsatisfactory communication with physicians [37,38].

A study performed by Tsahakis et al. demonstrated the ability to obtain health literacy following orthopaedic trauma, when appropriate interventions are implemented[39]. The authors provided informational packages (pictures and diagrams of a patient's injury and management), to one cohort, while the other cohort received standardized discharge summaries. In this prospective comparative cohort study, patients who received informational packages were more likely to appropriately name which bone was fractured and what medications they were prescribed for thromboprophylaxis[39]. Interestingly, there were no differences in comprehension of these packets between patients with different educational levels. This suggests that if proper interventions are

Table 5
Differences in mean long-term functional outcomes between educational groups and income groups. Higher SMFA scores are associated with worse outcomes.

Functional/Pain Score	Income <$50,000	Income >$50,000	p-value	Lower education	Higher education	p-value
Function	21.8 ± 9.7	15.2 ± 9.4	0.001**	23.9 ± 11.2	15.6 ± 11.9	<0.001**
Bothersome Index	24.7 ± 10.2	15.6 ± 9.6	<0.001**	27.1 ± 12.3	16.4 ± 11.9	<0.001**
Daily Activities	28.8 ± 11.3	20.4 ± 11.5	0.004**	31.5 ± 16.2	20.8 ± 15.8	<0.001**
Emotional Status	27.3 ± 14.2	17.7 ± 10.2	<0.001**	28.8 ± 15.4	19.5 ± 14.9	0.001**
Mobility	25.7 ± 13.5	17.2 ± 9.9	0.001**	27.4 ± 9.6	18.4 ± 10.0	0.001**
Total SMFA	22.2 ± 11.2	15.3 ± 9.5	0.002**	24.7 ± 13.8	15.4 ± 12.6	<0.001**
VAS pain score	4.1 ± 0.8	3.2 ± 0.7	0.003**	4.0 ± 0.7	3.1 ± 0.6	0.002**

** Signify statistically significant differences, utilizing P < 0.05.

undertaken, such as providing easy to understand fracture and recovery information, patients may have a better grasp of their injury. Implementation of such strategies, may have a positive effect on patient outcomes following surgical management of (fracture) non-unions.

The current study did not demonstrate any differences between ethnic groups in regards to clinical outcomes following surgical management of (fracture) non-unions. This is in contrast to studies of other orthopaedic conditions, which have reported that Non-Caucasian patients experience suboptimal outcomes following orthopaedic surgery [8–22]. One analysis of Medicare data demonstrated that African-Americans have poorer short-term outcomes following joint arthroplasty, in regards to increased readmission rates and post-operative complications [8,13–15,18,20].

There are several limitations with our study. Although an assessment was obtained prior to the surgical management of (fracture) non-unions, we do not have pre-initial injury baseline functional scores. For this reason, we cannot comment on return to pre-injury baseline function, only improvement compared to baseline at established fracture nonunion. Further, insurance status was unavailable for all patients, and could contribute to worse outcomes. However, insurance status is likely highly associated with income level, and therefore is inherently accounted for when assessing income level among our patients. Lastly, socioeconomic status was determined by self-reported income. This could be confounded by retired patients who report little income, yet they received a high education, and may have a stable financial foundation due to previous work and financial success. This study also included college students who reported no incomes, yet they may receive support from their families. We therefore performed a multivariate analysis to isolate independent predictors of outcomes following surgical management of (fracture) non-unions.

While ethnic disparities did not exist in this study, educational and economic disparities did play a role in predicting outcomes following surgical management of (fracture) non-unions. The demographic with the largest influence on negative outcomes was lower educational status. Additionally, an annual income of less than $50,000 also had a negative association with functional scores and pain. Orthopaedic trauma surgeons should therefore be aware of disparities may affect these outcomes and consider early interventions aimed at optimizing patient recovery. Being able to identify factors that lead to poorer outcomes, such as lower income and a decreased educational level is salient knowledge for medical professionals. Awareness of disparities in health care allows providers to implement early interventions, aimed at improving patient's recoveries following surgical management of (fracture) non-unions. Additionally, physicians may further utilize this information when managing patient expectations with regards to postoperative outcomes. Finally, future studies should be performed to assess if educational interventions negate the inexorable and deep-rooted disparities, which exist in our countries health care system.

Conflict of interest

K. A. Egol has been involved in the following relevant financial activities outside of this work and/or other relationships or activities that readers could perceive to have influenced, or that give the appearance of potentially influencing, this manuscript:

- Exactech – Royalties.
- Slack Inc & Lippincott – Royalties.
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D.N. Kugelman, J.M. Haglin, K. Carlock and S.R. Konda certify that they have no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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