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The Role of Classifications and Measurements of Kyphotic Angle in the Treatment Methods of Upper and Middle Thoracic Vertebral Fractures after Trauma

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ABSTRACT

Background and Aim: Thoracic fractures can lead to death and disability. This retrospective study aimed to evaluate cases of upper and middle thoracic vertebral fractures due to trauma that had been treated, to determine the fracture type and treatment method according to age, sex, cause of injury, neurological status, fracture level, kyphotic angles, and classification methods and to discuss the results regarding that reported in the literature.

Patients and Methods: This study included 238 patients who were evaluated for post-traumatic upper and middle thoracic vertebral fractures between January 2012 and December 2020. We classified each patient according to the Dennis, TLICS, ATLICS, and ASIA classifications using neurological examination, radiography, computed tomography, and magnetic resonance imaging. We statistically evaluated the data obtained.

Results: Fifty-five percent of total patients were male. The average age was 51.11. Traffic accidents were the most common causes of trauma, with 67.2%. T8 was most affected. The ASIA classification, the Dennis, TLICS, and ATLICS classifications showed a significant increase in the severity of neurological deficits as the fracture scores increased ($p < 0.001$). We observed that the increase in the preoperative kyphotic angle caused an increase in the number of deficits according to the classifications ($p < 0.001$).

Conclusion: The ATLICS classification yielded more accurate results than that of the other classifications. In addition, the kyphotic angle was evaluated for upper and middle thoracic fractures, and we concluded it is important in surgical decision making.

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KEYWORDS

Thoracic vertebra; fracture; AO spine; TLICS classification; kyphotic angle

Introduction

The cost of treatment for emergency surgery due to spinal trauma and spinal cord injury is high, and spinal trauma and cord injuries have effects, such as long-term hospitalization, physical rehabilitation, and medical treatment. Therefore, there are several ongoing studies worldwide to improve clinicians' understanding of spinal cord injuries, clinical signs, and complication patterns, increasing survival and reduced the cost of treatment[1].

In Türkiye, 1,800 new cases of spinal injuries occur annually, and an average of 54,000 people remain disabled because of the spinal injuries. Spinal injuries occur 3–4 times more frequently in men than in women, and the most common causes are motor vehicle accidents (40–50%), level-ground falls (10%), falls from a height (20%), work accidents (18%), fire-arm injuries (5–15%), sports accidents (4%), and other causes (3%)[2].

The evaluation and treatment of fractures should be performed with care because of the anatomical and biomechanical condition of the thoracic spine after spinal injuries. Since the thoracic spine angle is kyphotic, the spinal canal is narrow, and neurological deficits are more common after thoracic spine fractures [3,4]. This makes the evaluation and treatment of thoracic fractures important. Many classification methods have been developed because of the complexity of the anatomy and biomechanics of the thoracic spine. Among these classifications, ASIA, Denis/McAfee, ATLICS and TLICS are the most commonly used [5,6]. Previous studies could not establish the superiority of one classification over the other[7].

This retrospective study aimed to evaluate cases of upper and middle thoracic vertebral fractures due to trauma that had been treated, to determine the fracture type and treatment method according to age, sex, cause of injury, neurological status, fracture level,

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kyphotic angles, and classification methods and to discuss the results regarding that reported in the literatures.

Patients and Methods

The ethics committee of our university approved this study with the decision dated 05.02.2021 and numbered 2021/117.

This study included 238 patients diagnosed with upper (T1– 4) and middle (T5– 8) thoracic vertebral fractures, who were treated at Turkiye, Afyonkarahisar University of Health Sciences, Faculty of Medicine, Department of Neurosurgery in the University Hospital between January 2010 and December 2020. The inclusion criterion was thoracic fracture due to trauma. Patients with pathological fractures due to malignancy or other non-traumatic causes were excluded from the study. Included patients had a follow-up period of at least two years.

Radiography, computed tomography (Toshiba Aquilion Prime [80 × 2], Toshiba Medical Systems, Japan), and magnetic resonance imaging (1.5 Tesla power MRI device-Philips Intera, Philips Medical Systems, Best, Netherlands) were performed when the patients were admitted to the hospital. Each patient was surgically or medically treated. We evaluated and classified patients based on the Dennis, TLICS, ATLICS, and ASIA classifications and compared the results with those reported in the literature.

We transferred the data to the IBM SPSS 23 program. The normality assumption of continuous variables was examined, and analyses were selected according to whether we met the normality assumption. We summarized categorical variables as frequencies and percentages, and continuous variables as means, standard deviations, and minimum-maximum. An independent sample t-test was used to compare the normally distributed two-level continuous variables, and the Mann-Whitney U test was used to compare non-normally distributed two-level

continuous variables. We examined the relationships between categorical variables using the Chi-square analysis/Fisher's exact test. A p-value of <0.05 was considered statistically significant.

Results

Demographic distribution

Of the 238 patients, 131 were male and 107 were female, with a mean age of 49.59 and 52.96 years, respectively, and the overall mean age was 51.11 years.

166 patients with a mean age of 47.39 years were admitted due to road traffic accidents and 72 with a mean age of 59.68 years were admitted due to falls. We observed no significant difference between the sexes of each cause of fracture ($p > 0.05$). We observed a significant correlation between the cause of fracture and age ($p < 0.001$).

Evaluation according to Dennis' Classification

Based on the Dennis Classification, 106 patients with compression fractures were classified as type 1, 92 patients with burst fractures as type 2, 20 patients with seat belt fractures as type 3, and 20 patients with fracture dislocation as Type 4. The classification subgroup distribution is shown in [Figure 1](#).

When the fracture types were compared with the kyphotic angle at first presentation, the median kyphotic angle was 12° for Type 1 fractures, 21° for Type 2 fractures, 24° for Type 3 fractures, and 26° for Type 4 fractures. The relationship between the fracture type and preoperative kyphotic angle in the Dennis classification was significant ($p < 0.001$) ([Table 1](#)).

We performed surgical treatment for 1.88% of Type 1 fractures, 79% of Type 2 fractures, and all Type 3 and Type 4 fractures. The relationship between the type of fracture and the need for surgery in the Dennis classification was significant ($p < 0.001$). One of the two patients who underwent surgery for Type 1 fractures underwent kyphoplasty and the others underwent short segment (three levels) stabilization. In Type 2

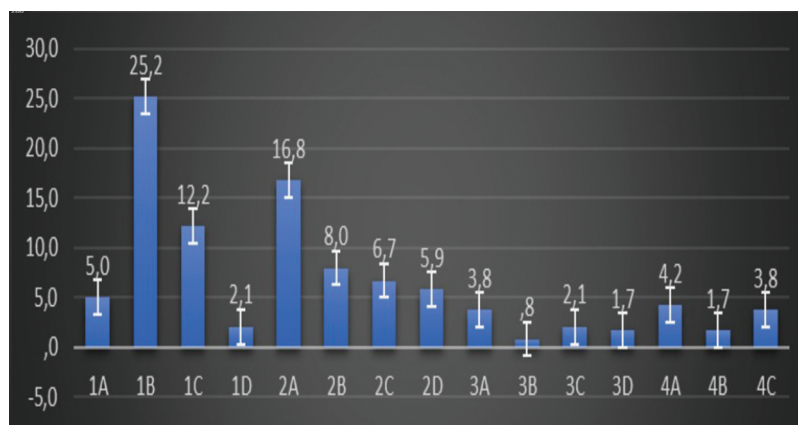


Figure 1. Distribution of patients according to Dennis' classification.

Table 1. The relationship between fracture types in Dennis classification and the kyphotic angle at first presentation.

Dennis classification	Minimum	Maximum	Average Value
Type 1	8	26	12,00
Type 2	8	45	22,00
Type 3	13	35	24,00
Type 4	16	37	26,00

fractures, all the 72 patients were instrumented, and the levels of stabilization were from three to eight, with a median of 5 levels. In type 3 fractures, 20 patients underwent surgery, and the level of instrumentation was from four to seven, with a median of 5 levels. In Type 4 fractures, 20 patients underwent surgery, and the level of instrumentation was from five to seven, with a median of 5.5 levels. The relationship between the fracture type and the number of instrumentations in the Dennis classification was significant ($p = 0.001$).

Evaluation according to the TLICS Classification

According to the TLICS classification, 122 (51.3%) scored 3 or less, 27 (11.3%) scored 4, and 89 (37.4%) scored 5 or more (Figure 2).

Three of the patients with a score of 3 or less, 24 of the patients with a score of 4, and all the 81 patients with a score of 5 or above underwent surgery. The relationship between the scores obtained in the TLICS classification and surgical decision-making was significant ($p < 0.001$) (Table 2). Kyphoplasty was performed for one patient with a score of 3 or less, and vertebroplasty was performed for the other two patients. Vertebroplasty was performed for one patient with a score of 4 and instrumentation was performed for 23 patients, with levels from three to five. All the 81 patients who scored 5 or more were instrumented, and stabilization was performed from three to eight levels. The relationship between the score obtained in the TLICS classification and the number of instrumentations was significant ($p < 0.001$).

When the TLICS classification and kyphotic angle were evaluated, the mean kyphotic angle was 12.01° in patients with a score of 3 or less at the first admission,

Table 2. The relationship between surgery and the score values of the patients in TLICS classification.

TLICS POINTS	Surgery number/rate	Follow-up number/rate	Total number/rate
3 or less points	3/% 2,45	119/% 97,54	122/%53
4 points	24/% 88,88	3/% 11,11	27/%11.7
5 or above points	81/% 100	0	81/%35.3
Total	108/%47	122/%43	230

21.11° in patients with a score of 4, and 24.06° in patients with a score of 5 or above (Figure 2). The relationship between the score obtained in the TLICS classification and kyphotic angle at the first admission was significant ($p < 0.001$).

Evaluation according to the ATLICS Classification

Of the 238 patients, 123 (51.7%) scored 3 points or less, 7 (2.9%) scored 4 and 5 points, and 108 (45.4%) scored 6 points or more. We performed surgical treatment for 3 of the 123 patients with a score of 3 or less, five out of seven patients with a score of 4 and 5, and all the 108 patients with a score of 6 or above (Figure 3). Using the Monte Carlo simulation model, the correlation between the score obtained in the ATLICS classification and the surgical decision was significant ($p < 0.001$).

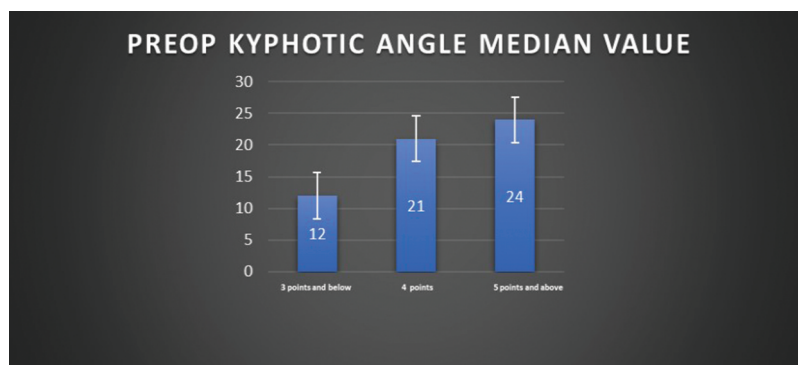
When the kyphotic angle was evaluated at the first admission, the mean kyphotic angle of the patients who scored 3 or less was 12.54° , 4 and 5 was 20.14° , and 6 and above was 24.72° . The relationship between the score obtained in the ATLICS classification and the preoperative kyphotic angle was significant ($p < 0.001$).

Spearman's correlation showed a weak but significant correlation between the number of surgical instrumentation and the ATLICS scores ($r = 0.283$, $p = 0.004$).

Evaluation according to the ASIA Classification

Of the patients included in this study, 192 (80.7%) were classified into the E group. Figure 4 shows the group distribution of the patients.

In the ASIA classification, the Dennis, TLICS, and ATLICS classifications showed a significant increase in the severity of neurological deficits as the fracture scores increased ($p < 0.001$). We observed that the

**Figure 2.** The relationship between the TLICS classification scores and the preoperative kyphotic angle.

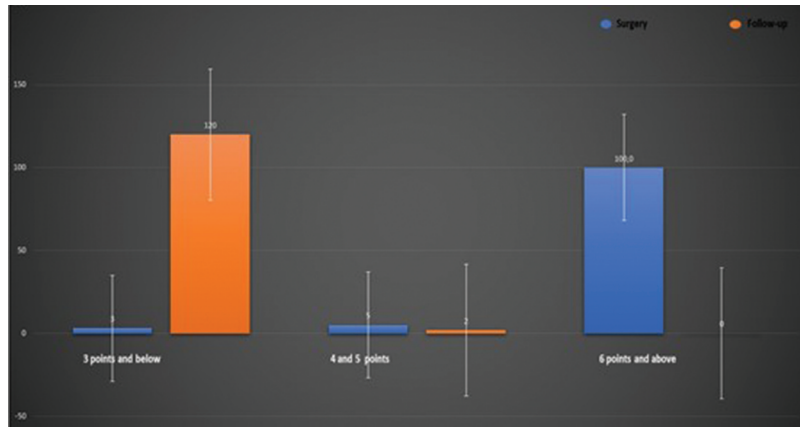


Figure 3. The number of surgeries and follow-ups according to scores in ATLICS classification.

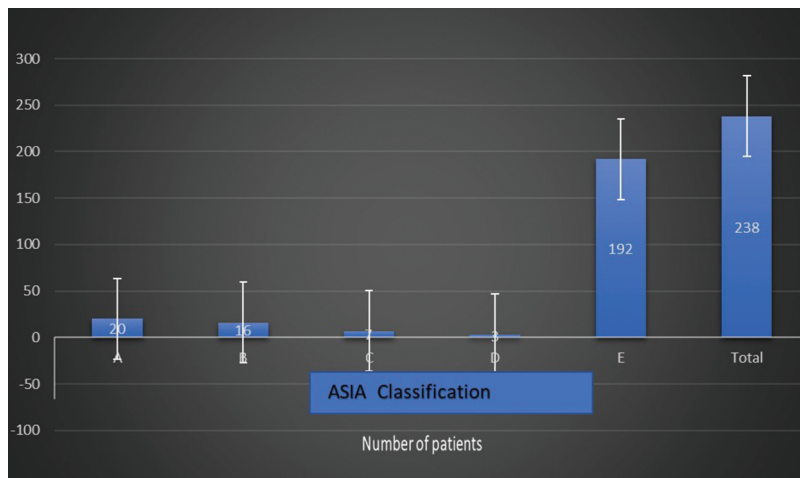


Figure 4. Distribution of patients in Asia classification.

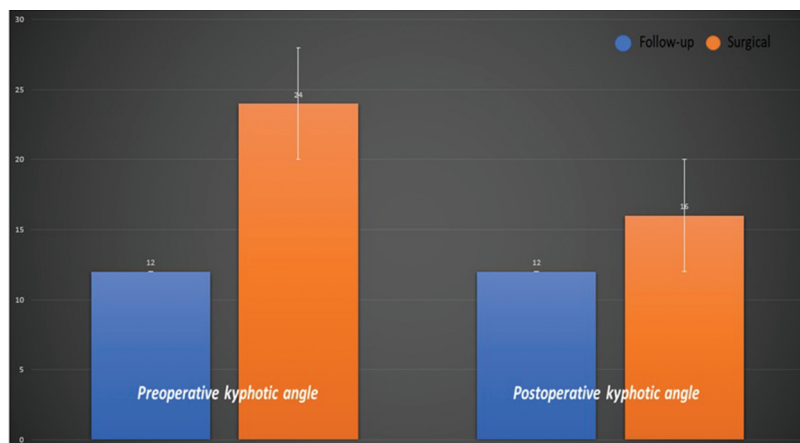


Figure 5. Evaluation of preoperative and postoperative kyphotic angle values according to follow-up and surgical treatment.

increase in the preoperative kyphotic angle caused an increase in the number of deficits according to the ASIA classification ($p < 0.001$).

Kyphotic angle assessment

The mean kyphotic angle of 122 patients who were followed up was 12.60° at the first admission and 12.94° at the end of the follow-up. A mean preoperative and

postoperative kyphotic angle of 24.06° and 16.90°, respectively, was observed in 108 patients who underwent surgery (Figure 5). Based on the classifications, the kyphotic angle did not progress in the during the follow-up period, but there was a decrease in the kyphotic angle after the surgical procedure ($p < 0.001$).

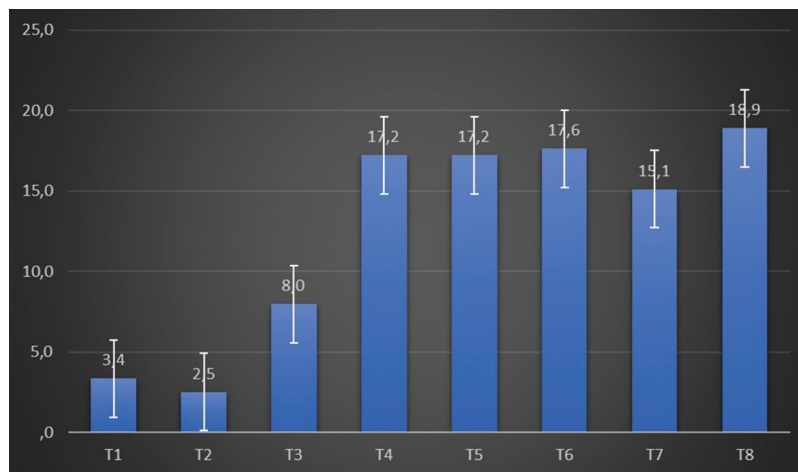


Figure 6. Percentage graph of fracture levels.

When examined the patients according to the level of the vertebral fracture, T8 fractures were the most common and T2 fractures were the lowest (Figure 6).

Discussion

In our study, Dennis, TLICS, ATLICS, and ASIA classifications were considered. After this classification, either surgical or medical treatment was applied. Classification of vertebral fractures informs surgical decisions. Previous studies have reported that successful results can be obtained with conservative treatment after fractures, regardless of the mechanism and type of fracture. [12] Medical treatment was performed for 53.04% of our patients, and surgery was performed for 46.95% of the patients.

In North American and European studies, the mean age of patients with thoracic fractures was 29.7 years, and the female-to-male ratio was 1:4. [8] In a study conducted in Japan, the mean age was 48.6 years. [9] In Turkey, Zileli et al [10]. reported a mean age of 35.1 years. In our study, the female-to-male ratio was 1:1.3, and the mean age was 51.11 years.

The studies by Cotler et al., Dickson et al. and Surkin et al., reported a percentage of motor vehicle accidents to be 47.8%, 28.5% and 41%, respectively, and falls to be 38.5%, 31.6% and 10.1%, respectively [11–13]. Knop et al. included 682 patients in their study, and falls (50%) and traffic accidents (22%) were reported as the most common causes of thoracic vertebral fractures [14]. In our study, thoracic fractures occurred in 69.7% of the patients due to traffic accidents and 30.3% of the patients due to falls from a height. The mean age of those who had traffic accidents in our study was significantly lower than that of those who fell, showing that the young population is prone to traffic accidents and the elderly population to falls.

In the study by Magerl et al., type 1 B was observed to be the most common type of fracture (66.16%) according to Dennis' classification [15]. In our study, we observed that 25.12% of the patients had type 1 B fracture, Our result compatible with the literature. When evaluated according to the Dennis classification, surgical treatment was performed for 2% of type 1 fractures, 72% of type 2 fractures, and all type 3 and 4 fractures. We recognized the surgical necessity for types 3 and 4 fractures. However, in types 1 and 2, a clear distinction cannot be made between the choice of surgical and medical treatment. We concluded that Dennis' classification is practical but unreliable. The Dennis classification significantly correlated with the preoperative kyphotic angles, such that as the fracture type progressed, the kyphotic angle increased as well as the need for surgery increased.

TLICS is the first classification system that includes the neurological status of patients. In the TLICS classification, patients with a score of less than 3 underwent medical treatment, patients with a score of 4 underwent treatment based on the preference of the surgeon and the patient, and patients with a score of 5 or more underwent surgery [16].

In this study, the TLICS classification provided a clearer idea of the surgical decision than that provided by Dennis' classification. However, the percentage of patients with a score of 4 was 11.3%, showing that the classification was insufficient. When the preoperative kyphotic angle was correlated with the TLICS scoring, we observed that the kyphotic angle increased as the score increased. Compared to the ASIA classification, the deficit rate and the level of instrumentation increased as the TLICS score increased, and the results were compatible with that in the literature.

Because of the inadequacies of the TLICS classification, in 2013, Vaccaro et al. published the ATLICS by revising the TLICS classifications [17]. Conservative

treatment is recommended for those with an ATLICS score below 4, and surgical treatment is recommended for those with an ATLICS score above 5, according to the preference of the patient and the surgeon[17]. In our study, three patients who underwent surgery with a score of less than 3 according to the ATLICS were treated with wig kyphoplasty. In addition, for an ATLICS score of 4 and 5, the kyphotic angle was considered when the choice had to be made by the patient and the surgeon. When the preoperative kyphotic angle was evaluated in the ATLICS classification, we observed that as the ATLICS score increased, the kyphotic angle and the number of instrumentations also increased. The ATLICS was less positive than that of the TLICS classification. However, the kyphotic angle, which is important in surgical decision-making, would have been more effective if we had included it in the ATLICS classification.

One of critical problems after vertebral fractures is progressive kyphosis. The local kyphosis angle was measured as the angle between the parallel lines drawn to the upper and lower endplates of the fractured spine[18].

In the study by Shen et al., there was a 6-degree increase between the last radiograph and first radiographs at the time of diagnosis[19]. Çelebi et al. observed a significant difference between the angles measured on radiographs at the time of diagnosis and at the final follow-up[20]. Tonbul et al. observed a significant decrease in sagittal index and local kyphosis angle at the time of diagnosis and after plaster cast, but they did not observe any significant difference between the values at the last follow-up and at the time of diagnosis[21]. One of the most important goals of treatment is to correct the kyphotic angle. A progressive kyphotic angle can cause persistent back pain and a deficit[22]. When preoperative and postoperative kyphotic angles of the patients were evaluated, we found that the mean kyphotic angle of the patients we followed up on who received medical treatment was 12.6° at the first admission and 12.94° at the last follow-up. In patients who underwent surgery, the mean kyphotic angle was determined as 24.06° at the first admission and 16.90° postoperatively. The improvement in kyphotic angle observed in the patients who underwent surgery was significant. In addition, we observed that the improvement did not progress during the follow up. The results were compatible with those reported in the literature.

The ASIA classification is a useful classification for evaluating patients with spinal cord injuries owing to traumatic thoracolumbar fractures determining treatment options, and for managing their follow-up process[23]. According to the ASIA classification, we observed in our study that there were 8.4% of the patients in group A, 6.7% in group B, 2.9% in group C, 1.3% in group D, and 80.7% in group E.

When the ASIA classification was evaluated statistically using the Dennis, TLICS, and ATLICS scores, the amount of deficit increased as the fracture score and preoperative kyphotic angle increased. These results are in agreement with those in the literature.

Conclusion

In our study, the ATLICS classification yielded more accurate results than that of the other classifications. In addition, the kyphotic angle was evaluated for upper and middle thoracic fractures, and we concluded it is important in surgical decision making.

Abbreviation

TLICS: Thoracolumbar injury *classification* system

ATLICS: The *AO Spine* thoracolumbar injury *classification* system

ASIA: The American Spinal Injury Association

Disclosure statement

No potential conflict of interest was reported by the author(s).

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