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Comparison of functional and medical assessment in the classification of persons with spinal cord injury

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Abstract—For many reasons, persons with spinal cord injury (SCI) are classified according to a set of guidelines in which the term classification refers to a numeric value based on some selection of motor, sensory, and/or functional tests. The resulting classification is used as a means of quantifying the extent of neurological injury. Scales that focus on neurological injury (in the acute phase) differ from those that focus on functional ability (in the chronic phase). The relationship among these scales in grouping persons with SCI has not been ascertained. The purpose of the present study was to compare several classification systems within the same group of spinal cord injured subjects. Thirty subjects with traumatic SCI were classified by the same examiner and grouped according to three classification systems: 1) the American Spinal Injury Association (ASIA) Scale; 2) the Bracken Scale; and, 3) the wheelchair basketball (BB) Sports Test. Calculation of Spearman's Rho correlation coefficients showed positive associations between the ASIA Scale and BB Sports Test (0.81). The Bracken Scale showed a negative correlation with the ASIA system (−0.66) and the BB Sports Test (−0.48). Of the three classification systems, the ASIA Scale showed the greatest discrimination in grouping subjects with SCI in both mixed (complete and incomplete), as well as incomplete injuries. It was clear that these three systems could result in different patterns of subject grouping and thus might affect the outcome of the clinical research studies.

Key words: *classification, spinal cord injury.*

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INTRODUCTION

Many classification systems have been developed to group spinal cord injured (SCI) subjects in the clinical, research, and sports settings. The purpose of classification in the clinical and research settings is to group subjects according to some numeric score to permit mathematical evaluation of treatment or injury outcomes or to identify characteristics of a group that would permit between-group comparisons. In sports, the aim is to permit fair competition among athletes.

The clinical and research environments have produced many classification systems, all based on the medical model of disability; that is, a neurological assessment based on isolated manual muscle and sensory testing. The trend in classification has been toward greater and greater complexity. Presumably, greater complexity would increase the sensitivity of the scale and therefore enable a more precise interpretation of research results.

Several investigators have expressed their concerns about the inadequacies of the medical systems currently in use. Reynier (1) and Frankel (2) commented on the difficulties in comparing treatment outcomes between different studies that used different classification systems to group their subjects. Stauffer (3) described the limitations of a number of medical classification systems in categorizing individuals with incomplete SCIs. Bracken (4) described the difficulties with classification systems that use a simple summation of scores from testing different muscles when the contribution of each muscle might

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not, in fact, be equal. Young (5) and Bracken (6) noted the time and expense involved in the repeated neurological assessments required by classification systems such as those used by the National Acute Spinal Cord Injury Study (NASCIS). A modification of the NASCIS classification system was developed by Bracken (7) in an attempt to increase the sensitivity and facilitate the use of that system. Botsford (8) stated that there was a need for more functionally oriented classification systems and then proceeded to propose another classification system based on traditional motor and sensory testing with the inclusion of bowel and bladder indices.

According to Steadward, the sports classification systems, of which there are also many, place a greater emphasis on functional ability (9). Brasile and Cooper report that organizations involved in sports for people with disabilities and led by the International Stoke Mandeville Games Federation have rejected the medical model of an individual as being the mere sum of his/her parts and have developed several functionally oriented sports classification systems (10,11,12). Labanowich (13) reports that the wheelchair basketball classification system introduced in 1986 by Strohkendl (14) was the first such functional system. This was followed by functional classification systems for wheelchair track (15), field, rugby, and wheelchair table tennis (16).

Despite the fact that many medical and sports classification systems exist, concerns about the validity of these systems and system usage criteria persist. In fact, there are no published attempts to compare different systems to see if they would classify persons similarly. From the clinical research position, this makes the selection of an appropriate scale difficult. For example, if one were examining the characteristics of the wheeling style of a group of nonathletic subjects with paraplegia and quadriplegia, would it be appropriate to present data from each group based on a medical or on a functional classification system? While recognizing that current classification is quite different from this global vision, Ditunno (17) has argued for a universal classification system.

The present study was designed to use three systems to compare the classification of the same group of subjects, tested by the same examiner. The goal was to determine whether the resulting classification would be different for each individual depending on the system.

METHODS

Subjects

The subjects were 30 individuals (26 males and 4 females) with traumatic SCI and were recruited from a local rehabilitation center and community. Each one used a manual wheelchair for basic mobility. All subjects volunteered for the study and gave informed consent before participation.

The physical and medical characteristics of each subject are summarized in **Table 1**. The mean age of the group was 39 years with a range from 20 to 50 years. The mean time since injury was 74 months (6.2 years) with a range from 4 months postinjury to 203 months (17 years) postinjury. Individuals with complete and incomplete injuries were included in the study group.

Assessment

All subjects were assessed by the same tester, a physiotherapist experienced in medical and functional assessment techniques. Complete neurological, functional, and sports testing were done on the same day and in the same order. The classification systems used were: 1) the American Spinal Injury Association (ASIA) Scale; 2) the Bracken Scale; and, 3) the Basketball (BB) Sports Test.

ASIA Scale. The ASIA Scale is described in the revised *1990 Standards for Neurological Classification of Spinal Injury Patients* (18). It consists of a motor index score based on muscle grades (0–5) from a single muscle on both sides of the body in each of 10 myotomes. A maximum of 10 points is available from each myotome with a resultant total possible score of 100 points. Sensory testing is not quantified in this scale.

Bracken Scale. The Bracken Scale was developed in 1973 at the Yale University Spinal Cord Injury Center (6) to evaluate drug therapy in the acute stage of SCI. Its primary focus is to distinguish between complete and incomplete injuries. Subjects are grouped by neurological deficit from C1 to T1 and T2 to S5. The sensory scale ranges from 1 to 7 and the motor severity scale from 1 to 5. Different categories exist for complete and incomplete deficits in both the motor and sensory areas. This is an inverse scale with the maximal possible score of 12 relating to the lowest level of ability. The lowest possible score of 1 corresponds to an individual with the least impairment.

Table 1.
Physical and medical characteristics of the study group.

Subject Number	Neurological Level			Age (years)	Sex	Injury (months)
26	C5	C	Quadriplegia	24.0	Male	10
09	C6	C	Quadriplegia	36.8	Male	145
12	C6	I	Quadriplegia	29.0	Male	153
11	C6	I	Quadriplegia	33.7	Male	196
25	C6	I	Quadriplegia	33.2	Female	8
13	C7	C	Quadriplegia	25.7	Female	108
27	C7	C	Quadriplegia	38.2	Male	6
20	C7	I	Quadriplegia	32.1	Male	88
15	C8	C	Quadriplegia	34.4	Male	203
16	T1	C	Paraplegia	22.2	Male	36
06	T1	C	Paraplegia	22.5	Male	49
24	T4	C	Paraplegia	22.6	Male	20
18	T6	C	Paraplegia	39.0	Male	18
05	T6	C	Paraplegia	40.8	Male	72
01	T6	C	Paraplegia	19.9	Male	13
07	T6	C	Paraplegia	24.9	Male	48
30	T7	I	Paraplegia	23.4	Male	7
23	T8	C	Paraplegia	36.8	Male	8
02	T10	C	Paraplegia	24.5	Male	20
21	T11	C	Paraplegia	29.8	Male	5
22	T12	I	Paraplegia	40.8	Male	5
19	T12	I	Paraplegia	33.1	Female	160
10	T12	C	Paraplegia	32.1	Male	168
08	T12	C	Paraplegia	50.3	Male	87
03	L1	C	Paraplegia	45.3	Male	96
28	L1	C	Paraplegia	24.2	Female	4
04	L2	I	Paraplegia	24.7	Male	120
29	L2	I	Paraplegia	27.8	Male	4
17	L4	I	Paraplegia	32.4	Male	192
14	L5	C	Paraplegia	28.1	Male	105

C = Complete lesion, I = Incomplete lesion.

BB Sports Test. This classification system is based on three functional tests, first described by Strohkendl (14), which are used in the grouping of athletes for competition in wheelchair basketball. No isolated motor or sensory assessment is done. The first test requires the individual to be able to sit in a wheelchair with the back unsupported and bounce a basketball to the left and right sides of the chair. This task requires the presence of some trunk muscles that permit the individual to rotate the torso in space independently. The second test requires the individual to rise from a position of having the chest forward on the thighs to an upright position without using the arms. This test requires the presence of full torso musculature anteriorly and posteriorly as well as some hip muscle activity. The last test consists of picking up a ball placed on the floor beside the wheelchair, lifting it up and over the head and placing it on the opposite side of the chair. The presence of active leg and full hip musculature is necessary for the completion of this task. The possible range of scores in this system is from 1 to 4 points. A 1-point player corresponds to the individual with the greatest disability and a 4-point player to an able-bodied player.

ANALYSIS

Once the subjects were classified, the investigators compared correlations among the three scales. All scales were assumed to be ordinal. The ASIA score is based on the common unit of manual muscle testing. Although this type of scale does have a true zero (a grade of 0 corresponds to the absence of motor function), the intervals between grades are not equal; therefore, the scaling is not interval. The BB Sports Test is an ordinal scale with the score of each subject consisting of a simple tally; one either can perform or cannot perform the test. The Bracken Scale is ordinal because the increments switch between complete and incomplete quadriplegia and paraplegia and the intervals are not equal. The scale is a reverse-order scale with lower scores indicating higher levels of residual functioning.

The assumption of ordinal scaling is critical to appropriate analysis and inference as described by Merbits (19). Thus, the nonparametric, Spearman's Rho correlation coefficients were used in the analysis of the associations among the scaling systems.

To assess the impact of data from persons with an incomplete lesion, the subjects were divided into two groups: those with complete lesions only, and those with incomplete lesions. Twenty subjects had

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complete lesions, the remaining 10 had incomplete lesions. Spearman's Rho correlation coefficients were calculated for the two subgroups.

RESULTS AND DISCUSSION

Subjects represented a wide range of characteristics in terms of age, injury time, score on each scale and level of lesion. In addition, the subjects were selected to represent an average, nonathletic person with SCI. The distribution of all of the subjects within each scale is portrayed graphically in **Figure 1**. **Figure 2** shows the distribution of scores for the subjects with incomplete injuries, and **Figure 3** for those subjects with complete injuries.

The matrix of the Spearman's Rho correlation coefficients for the different classification systems is shown in **Table 2**, which has two parts. Cells with 30 subjects indicate the correlations when all data were pooled. Cells with 20 and 10 subjects indicate the correlations for the subgroupings.

The high, positive correlation between the ASIA Scale and the BB Sports Test of 0.81 is interesting. It is noteworthy that six subjects were ranked similarly and at the lower end of the ASIA and BB sports scales. Four subjects also had similar rankings (on the high end) in these scales. Maynard (20) found similar correlations between the ASIA motor score and a functional index score.

The correlations between the ASIA Scale and BB Sports Test with the Bracken Scale were negative, indicating that the Bracken scoring system is inversely related to the others. The correlations were low between the Bracken Scale and both the functional and the medical test (ASIA). The former is not surprising given the intent of the Bracken Scale. However, the latter is surprising because both the Bracken and ASIA scales were designed to quantify neurological injury in the acute phase.

The correlation coefficients in the subgroup with incomplete lesions are also shown in **Table 2**. They are lower for ASIA-BB Sports than in the larger mixed group. In contrast, the Bracken correlations with ASIA and BB Sports were all higher in the incomplete group than in the mixed group. This is not surprising, because the stated purpose of the Bracken Scale is to separate incomplete from complete injuries. However, even in the outlying subjects, the Bracken Scale classifies the individuals quite differently from the other systems.

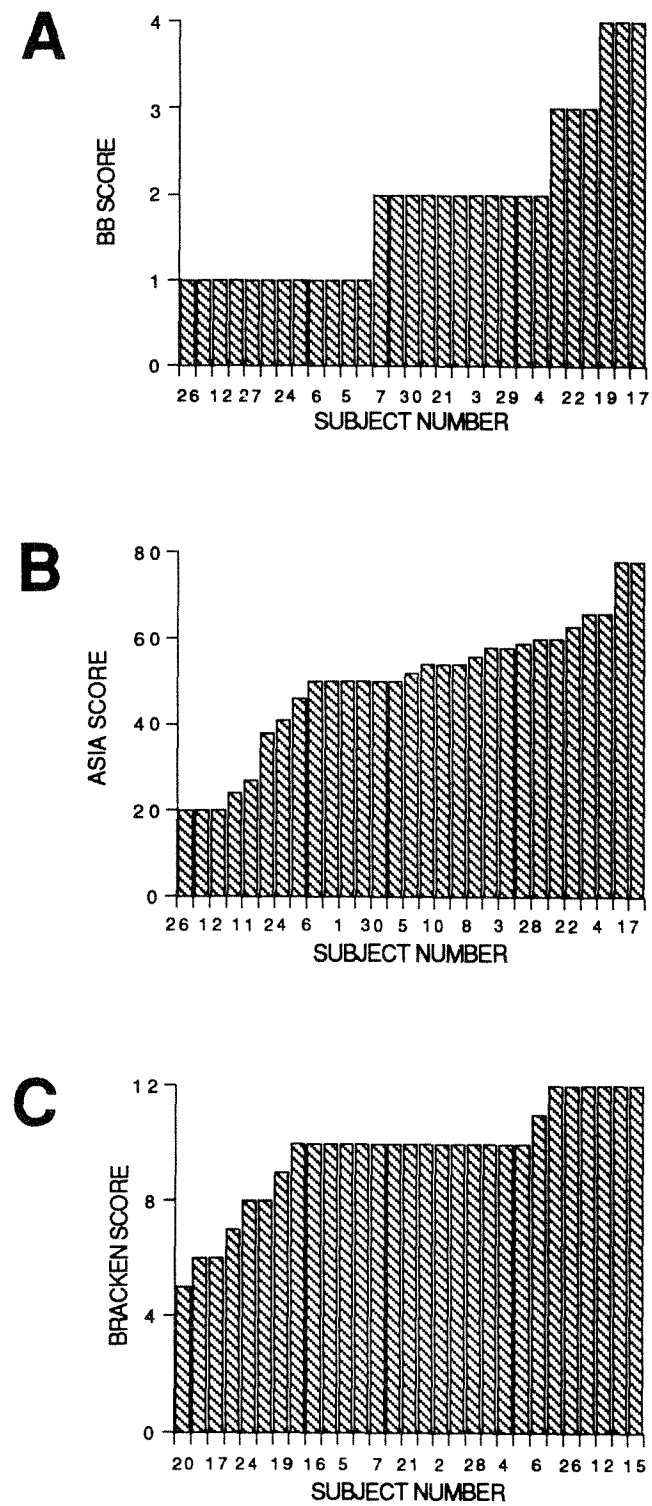

Figure 1.
These plots show the range of values obtained for (*A*) the BB Sports score, (*B*) the ASIA score, and (*C*) the Bracken score for the entire group of 30 subjects.

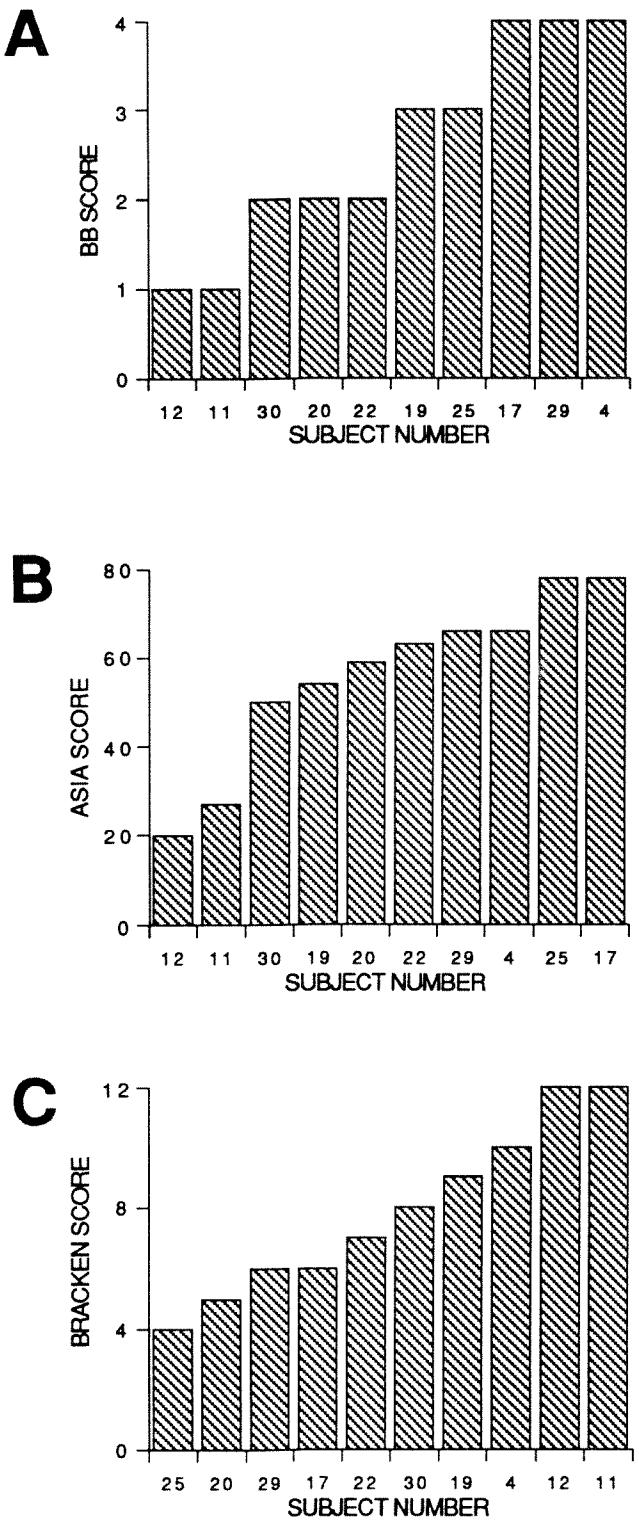

Figure 2.
These plots show the range of values obtained for (*A*) the BB Sports score, (*B*) the ASIA score, and (*C*) the Bracken score for the incomplete lesion group of 10 subjects.

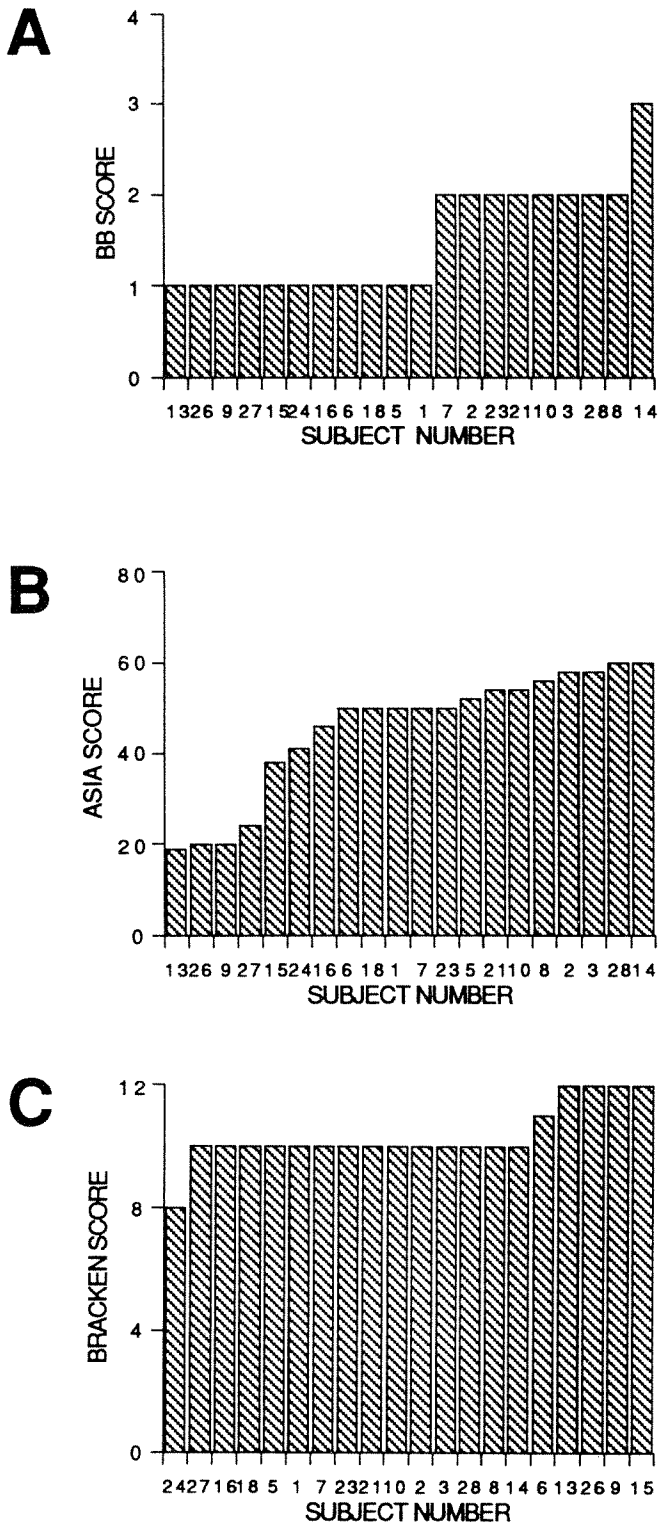

Figure 3.
These plots show the range of values obtained for (*A*) the BB Sports score, (*B*) the ASIA score, and (*C*) the Bracken score for the complete lesion group of 20 subjects.

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Table 2.
Matrix of Spearman's Rho correlation coefficients of three classification systems.

	ASIA			BB Sport		
	n = 30	n = 20	n = 10	n = 30	n = 20	n = 10
BB Sport	0.81	0.75	0.67			
Bracken	−.66	−.24	−.77	−.48	−.09	−.57

Three classification systems were compared in the same group of traumatic SCI subjects. The relatively high positive associations between the ASIA Scale and the BB Sports Test in both the mixed groups (0.81) and incomplete-only groups (0.67) are surprising inasmuch as both systems supposedly measure very different aspects of disability. The ASIA score, based on isolated muscle grades, may accurately reflect the ultimate functional ability of the person with SCI, and this is why the two scales correlate reasonably well. If that is the case, then one would argue for simple, functional tests as the most accurate reflection of residual ability following a spinal cord injury. Findings such as these would support the position of Brookes (21), Thiboutot (22), and Weiss (23) that for the purposes of athletic performance, the less complex classification systems are sufficient, or even desirable.

The BB Sports System, however, is unable to provide much sensitivity within a single category. For example, four subjects having quadriplegia with no hand or triceps function were grouped in the same category as three subjects who had high paraplegia with full hand and triceps function. That these individuals have similar athletic ability is interesting and suggests that smaller increments in classification are unnecessary.

The lower correlations between the Bracken and the other two scales are surprising. The Bracken Scale was designed to provide a sensitive index of recovery in the early postinjury phase. It may indeed be valid in this context, but in the framework of chronic disability, it does not seem to mirror disability in the same way as the other systems. Differences in neurological status and functional abilities of an individual with a complete C2 level of injury and a complete C8 injury, for example, are very considerable. Yet both individuals would be placed in the same category in the Bracken Scale. The Bracken Scale did show higher correlations with incomplete lesions than in the total group. Thus, it may be more sensitive at classifying individuals with incomplete injuries than the other systems.

Inclusion criteria for the study required that the subjects be able to propel their wheelchair. This implies a minimal neurological ability. Thus, conclusions about the three classification scales must be limited to individuals who met the requirements. Possibly the ASIA Scale is not as sensitive in classifying subjects who are unable to self-propel a wheelchair.

Quantifying the effects of SCI and resultant disability in the clinical research setting is necessary to develop data that are representative of a specific group of persons with disability. Although each person is unique, some patterns of motion represent a typical group response. Even though classification systems purport to rate or quantify disability or functional capacity, they rate the same individuals differently; thus, any attempt to group persons for the purpose of clinical research must be done with a view to the issues important to that research. If the grouping was done on the basis of complete or incomplete lesions, the resulting groups would be very different from grouping on the basis of a functional score on the BB test.

In summary, the data presented here illustrate that three popular classification systems quantify individuals quite differently. This implies that, for the purposes of clinical research, care must be taken in the selection of the system used to group the subjects, and that caution be exercised when interpreting any data from such studies.

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