Sardjito Scoring System for Open Fractures of the Lower Limb

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ABSTRACT

Gustilo Classification of open fracture is a widely used in Orthopaedic Surgery. However, it is still not universally accepted. Hence the author proposes a new evaluation system called the Sardjito Scoring System to decrease the inter-observer error observed when using the Gustilo Classification of open fractures.

One hundred and eighty six of lower limb fractures in one hundred and eighty six patients from January 1999 until December 2000 had been classified according to Gustilo Classification. Patients were admitted to the Emergency Department, Sardjito Hospital. They were also evaluated according to the Sardjito Scoring System by residents.

The results of the classification made by residents were utilized to measure the validity and reliability of the Sardjito Scoring System. We calculated the sensitivity, specificity, and accuracy, positive and negative predictive values from the results of classification made by residents.

The results of one hundred and eighty six open lower limb fractures were statistically analyzed. The Sardjito Scoring System was found to be valid (r ranged 0.6668 – 0.9864, p 0.01) and reliable (r ranged 0.9117 – 0.9977, $p<0.01$), the sensitivity: 98.31%, specificity: 81.10%, accuracy: 86.56%, positive predictive value: 70.73%, and negative predictive value: 99.04%. The results from the Gustilo Classification revealed the following: sensitivity 86.64%, specificity 32.8%, accuracy 49.46%, positive predictive value 37.23% and negative predictive value 83.67%. The results of infection rate in Sardjito Scoring System revealed the following : type I (0%), type II (1.1%), type IIIA (64.6%), type IIIB (87.6%), and type IIIC (100%) but according to Gustilo Classification the results revealed type I (5.3%), type II (23.3%), type IIIA (37.7%), type IIIB (30.4%) an type IIIC (70%).

The proposed Sardjito Scoring System was found to yield valid correlations, presented reliable and good diagnostic device for classifying the severity of open lower limb fractures.

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INTRODUCTION

There are many classifications in assessing, treating and predicting the outcome of open fractures. Some are superior in certain aspects than others. Specific methods for classification of open fractures continue to be topics of debate in orthopaedic traumatology. One of the most widely used classifications is the Gustilo Classification of open fractures.

Brumback and Jones showed that the level of agreement among 245 orthopaedic surgeons in classifying according to Gustilo Classification of open fractures of the tibia were only 60 percent.[1] Horn and Retting studied that the inter-observer reliability was moderate among the group tested.[2]

We are of the opinion that if a classification system is to be sufficiently detailed to be useful it will be too complex to be remembered and is therefore of limited value. It does not alter the fact, however, that excessively simple classification systems are often useless as they fail to fully define the problem. Despite its universal acceptability, the Gustilo system misses the "detail" to sufficiently define the severity of open fractures. This system contains many positive aspects in classifying open fractures such as by providing a workable system for defining the severity of injury, recognizing the difference between low and high energy trauma, stressing on soft tissue damage in particular on periosteal stripping, is of predictive value, and is adopted all over the world. Despite this, it lacks the detail so as to easily fall into doubtful situations when applied in an emergency setting which is in part because the classification is qualitative in nature, also it can possibly overlap among classes and it is subjective.

Because of that, we have proposed a new evaluation system called the "Sardjito Scoring System" with detailed scoring to quantitatively define the severity of open fractures, in particular the soft tissue damage, which contributes the most to predicting the outcome of the life and the function of the affected limb.

The lower limb is one of the most common sites of open fracture. It is fairly distinct from open fractures in general, partly because of the sparse soft tissue covering the tibia and the vascularity of the bone.[3]

The purpose of the present study was to evaluate the Sardjito Scoring System. We hypothesize that the Sardjito Scoring System is valid, reliable, sensitive, specific,

accurate and predictive in value and can avoid doubtful situation when applying open fracture classification.

METHODS

The study design was a diagnostic study. The residents of surgery in charge were asked to classify the severity of the injury; one according to the Gustilo Classification and the other to the Sardjito Scoring System (Tables 1, 2 and 3).

During the first 6 months, the same patients were assessed whether or not they were having infection according to clinical signs, laboratory and radiographic data.

Table 1. Description of the Gustilo Anderson Classification of Soft-Tissue Injury in Open Fracture

	Type I	Type II	Type III
Wound size	< 1 cm	> 1 cm	
Injury	Low velocity/energy	High velocity/energy	High velocity/energy
Soft tissue	Minimal soft tissue damage	No extensive soft tissue damage, flap, or avulsion	Extensive soft tissue damage, including muscle, skin and (often) neurovascular structures
Crush	No signs of crush	Slight to moderate crush	Extensive crush
Fracture	Usually simple, transverse or short oblique with little comminution	Moderate fracture comminution	Great degree of fracture comminution and instability
Contamination	Little contamination	Moderate contamination	High degree of contamination

Table 2. Description of the type III Soft Tissue Injury in the Gustilo Open Fractures Classification

	Type A	Type B	Type C
Injury	High velocity/energy	High velocity/energy	High velocity/energy
Soft tissue	Extensive soft tissue laceration, adequate bone coverage after debridement. Free flap are not necessary to cover bone. Segmental fractures, such as gunshot injury	Extensive soft tissue injury with periosteal stripping and exposed bone after debridement. Requires local or free flap to cover bone.	Same as type III B
Vascular Injury	Not significant	Not significant	Vascular injury requiring repair for limb salvage
Contamination	High degree	Massive	Massive

In order to support the hypothesis we did the validity, reliability test and the diagnostic studies. The diagnostic study includes sensitivity, specificity, accuracy, positive predictive value, and negative predictive value.

To study the validity and reliability, 32 open lower limb fractures of various severities from our file were presented to 11 residents of surgery. They were then asked to classify the severity of the injuries according to the Sardjito Scoring System and Gustilo Classification .

Every patient aged 20 to 60 years with lower limb open fractures who came to the emergency department of Sardjito Hospital Yogyakarta, from January 1999 to December 2000, were selected. Inclusion criteria was limited to patients who were otherwise healthy with isolated open lower limb fracture, aged between 20 to 60 years. Exclusion criteria was patients with other trauma, anemia, hypoproteinemia, diabetes mellitus, immunosuppressive medication and radiation, aged less than 20 or more than 60 years. For this study, we set the ideal sensitivity to at least 90% and specificity to at least 80% with a confidence interval of 95% (0.05), and acceptable deviation of about 10% for sensitivity and specificity respectively. Numbers of minimal sample size was 96.04. The gold standard was incidence of infection, counted within 6 months after the time of open fracture according to clinical signs, laboratory and radiographic data.

In validity and reliability tests, camera, ruler, multimedia projector, worksheet and computer were used. We used validity and reliability alpha. While in diagnostic study, ruler, worksheet, and computer were used. The results were calculated in cross-tabulation study.

RESULTS

Validity and Reliability

The radiographs, photographs and local condition assessment of 32 cases of lower limb open fractures were presented to 11 residents of surgery and scored by them according to Sardjito Scoring System.

The mean of corrected item total correlation of the skin condition for the skin, wound, muscle, neurovascular, bone condition and also contamination were shown in Table 4. The mean and reliability coefficient alpha for each item were bigger larger than r table ($r>0.4487$, $p<0.01$).

Table 3. Sardjito Scoring System Assessment

		SCORE
I	**SKIN DAMAGE**	
A.	**Wound**	
	< 5 cm (in out)	1
	5 – 10 cm long (out-in)	2
	10 cm	3
B.	**Condition of skin**	
	No devitalized edge of wound without contusion	1
	Contusion edge of wound/sub-cutan or with small area of degloving	2
	Large area of degloving or skin loss or skin avulsion	3
II.	**MUSCLE DAMAGE**	
	No muscle contusion or circumscribed muscle contusion or partial rupture	1
	Total rupture of one compartment muscle	2
	Muscle defect with extensive muscle crush	3
III	**BONE DAMAGE**	
	Simple fracture: transverse, oblique, spiral, butterfly or with little comminution	1
	Simple fracture with gross displacement, segmental fracture (little displaced) or moderate comminution	2
	Gross comminution, bone loss/defect	3
IV.	**NEUROMUSCULAR DAMAGE**	
	No neuromuscular trauma	1
	Isolated or localized neurovascular trauma	2
	Extensive neurovascular trauma	3
V.	**CONTAMINATION**	
	No particle	0
	Only superficial particle	5
	Deep particle	10

Note: add one for public watering accident or from farm accident or treated after golden period (10+1=11)

Grading

I Low energy, no particle
II Medium energy, moderate soft tissue damage and superficial particle
III High energy, severe soft tissue and bone damage and deep particle
- **A.** The fracture fragments can be covered by soft tissue or flap
- **B.** The exposed bone cannot be covered by muscle or skin
- **C.** Associated with vascular injury that require repair for survival of the limb

Total Score
5
6 – 15
16 – 26

Table 4. Validity and Reliability of each item in Sardjito Scoring System

	Corrected item total correlation	Reliability coefficient
Skin condition	0.9513	0.9759
Wound condition	0.8759	0.9759
Muscle condition	0.7934	0.9517
Neurovascular	0.6668	0.9117
Bone	0.8193	0.9610
Contamination	0.9864	0.9977

r = 0.4487 (df = 30, level of significance = 0.01)

Table 5. The classification by residents and medical students in group Sardjito Scoring System and residents and medical students in group Gustilo Classification and its infection rate compared to infection rate of original Gustilo series.

Type	Gustilo series	Sardjito Scoring System			Gustilo Classification assessed by residents and medical students		
		inf	total	% inf	inf	total	% inf
I	0 – 2%	0	9	0%	1	19	5.3%
II	2 – 7%	1	95	1.1%	7	30	23.3%
IIIA	7%	42	65	64.6%	23	58	39.7%
IIIB	10 – 50%	7	8	87.5%	21	69	30.4%
IIIC	25 – 50%	9	9	100%	7	10	70%

Diagnostic study

From January 1999 till December 2000, we found 186 cases met the inclusion criteria. All of them were classified by residents of surgery with Sardjito Scoring System and Gustilo Classification. Its infection rate was compared to the infection rate of the original Gustilo series (Table 5).

These results of infection rate showed that the more severe the types of open fractures, the higher the rate of infection in Sardjito Scoring System group. In the Gustilo group, there might be some disagreement among the observer in applying the assessment, especially between type IIIA (39.7%) and type IIIB (30.4%). In order to determine the cut-off point of the type, we used receiver operating curves ROC (Figures 1,2,3,4,5).

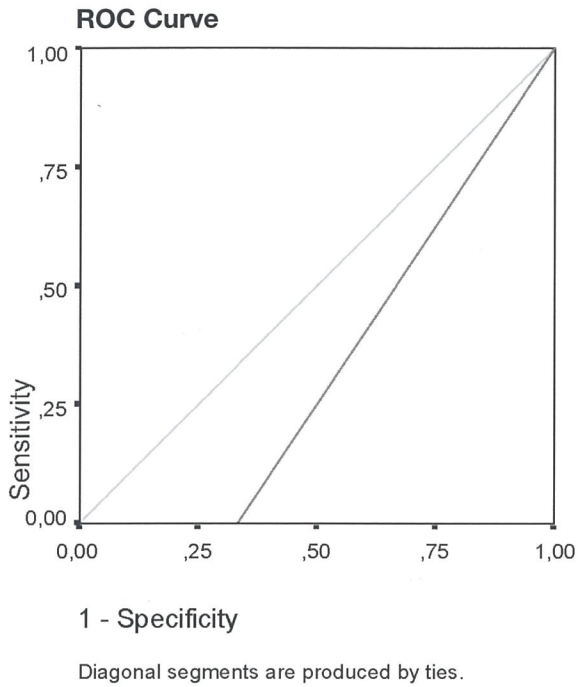

Figure 1. The receiver operating curve with the cut-off point at type I Sardjito Scoring System

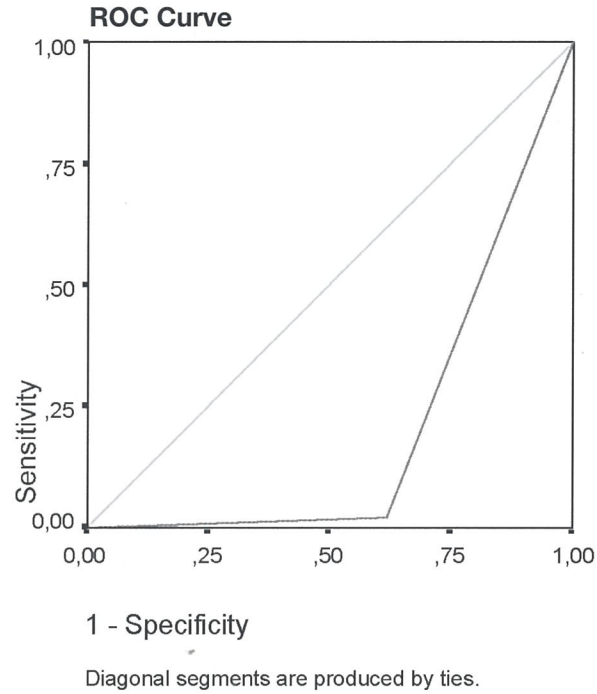

Figure 2. The receiver operating curve with the cut-off point at type II Sardjito Scoring System

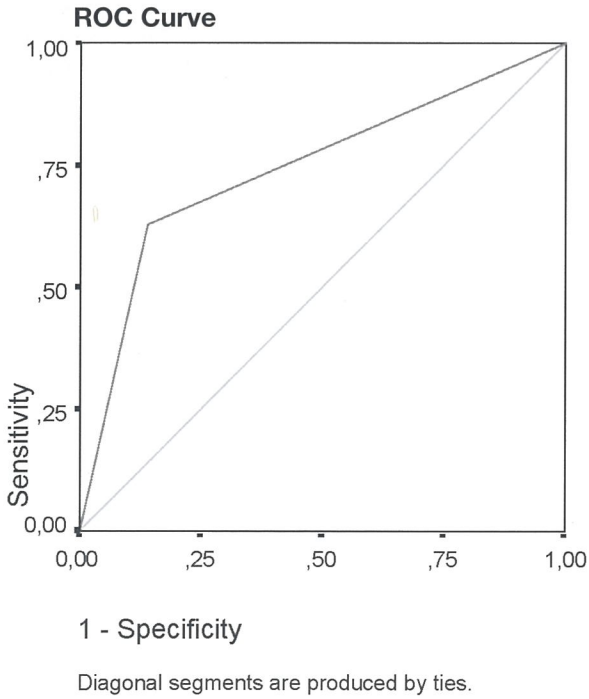

Figure 3. The receiver operating curve at the cut-off point at type IIIA Sardjito Scoring System

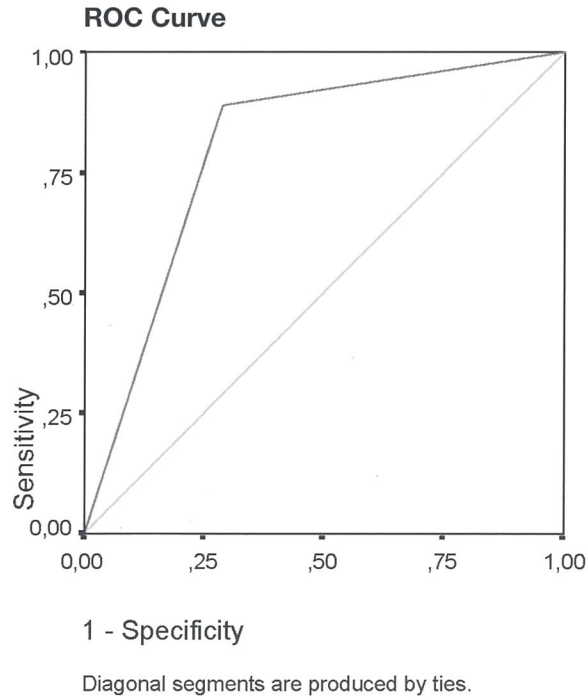

Figure 4. The receiver operating curve with the cut-off point at type IIIB Sardjito Scoring System.

From the ROCs the best cut-off point laid between type II and IIIA. According to their treatment, it is obvious that there are differences between type I + II and type III. According to the incidence of infection, it is clearly seen that after type IIIA there was a marked increase in the incidence of infection. We are of the opinion, finally, that the best cut-off point must lay between type II and IIIA. We further name it low energy trauma for type I and II, and high energy trauma for type III.

Low energy trauma comprising of type I and II resulted from low energy insult which produce only minimal bone and soft tissue damage leading to a low incidence of infection without the need for complicated treatment.

High energy trauma comprising of type III (IIIA, IIIB, and IIIC) is caused by sufficiently high energy insult, resulting in severe bone and soft tissue damage. It produces a high infection rate despite meticulous repeated debridement and intricate treatment. As a consequence, this group needs complicated, sophisticated, and prolonged treatment.

Based on this category, we made a cross tabulation for the incidence of infection assessed both with Sardjito Scoring System and Gustilo Classification (Table 6 and 7).

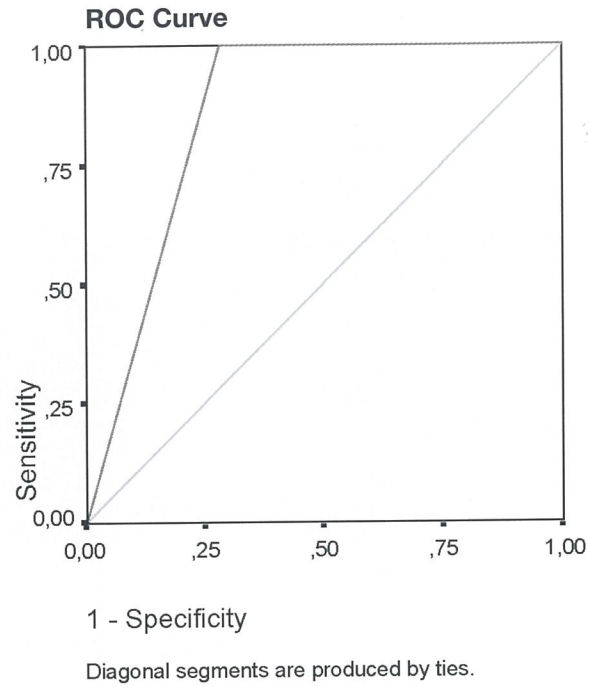

Figure 5. The receiver operating curve with the cut-off point at type IIIC Sardjito Scoring System.

Table 6. Cross tabulation of trauma energy versus incidence of infection with Sardjito Scoring System

	Infection	No Infection	Total
High Energy Trauma	58	24	82
Low Energy Trauma	1	103	104
Total	59	127	186

$X^2 = 103.049$ $p = 0.000$

Table 7. Cross tabulation of trauma energy versus incidence of infection assessed with Gustilo Classification of Open Fractures

	Infection	No Infection	Total
High Energy Trauma	51	86	137
Low Energy Trauma	8	41	49
Total	59	127	186

$X^2 = 7.279$ $p = 0.007$

From the cross tabulation for Sardjito Scoring System we found: sensitivity 98.31%, specificity 81.10% accuracy 86.56%, positive predictive value 70.73% and negative predictive value 99.04%.

From the cross tabulation for Gustilo Classification we found: sensitivity 86.44%, specificity 32.8%, accuracy 49.46%, positive predictive value 37.23% and negative predictive value 83.67%.

DISCUSSION

Sardjito Scoring System of open fractures was objective, reliable and applicable. In contrast, the Gustilo Classification which is widely used produced unsatisfactory level of compliance.

The results showed that Sardjito Scoring System has better sensitivity, specificity, accuracy, positive and negative predictive value than Gustilo Classification of open fractures. Sardjito Scoring System described open fracture according to some factors including skin damage (wound size and skin condition), muscle damage, bone damage, neurovascular damage, and contamination with variable score. All these factors highly influence the outcome of open fractures. [6, 7, 8, 9, 10]

The better correlation might be because the Sardjito Scoring System emphasizes on soft tissue damage where the micro-bacteria easily grow and from where the bones have their blood supply. From Gotham[11] and Rhinelander[12] studies, it is obvious that the "degree of soft tissue damage" has a dominant role after fracture as the source of extra-osseous blood supply. It is also evaluated on the severity of bone damage which is examined by x-rays to correlate with the soft tissue damage around the fracture site. Therefore, the appearance of the wound and the radiographs of open fracture will not mislead one into making a wrong assessment.

It should be borne in mind that the Gustilo Classification is qualitative in nature and is very subjective, making it prone to errors since it is vague for interpretation. Inspired by this fact, the Sardjito Scoring System was designed in detail taking into account all important factors of an open fracture.

We found high sensitivity of the Sardjito Scoring System in assessing open fracture, while its specificity is somewhat lower. It is not significant though, since a diagnostic device like Sardjito Scoring System is aimed to detect the presence of higher trauma rather than exclude it. The accuracy of Sardjito Scoring System was not very high. Accuracy could be misleading because it combined the test's ability to detect as well as its ability to exclude their presence of disease.

The positive predictive value of Sardjito Scoring System was not very high. In the clinical setting of open fractures, negative predictive value has better value than the positive one. Negative predictive value in this case was a probability of a patient having no infection when the test showed he/she had low energy trauma open fracture (Type I/II). Since the treatment of type I/II open fractures is similar to that of close fractures, it is very important for clinicians to be sure that the probability of these patients of having infection is negligible. Therefore, the probability infection rate is 0.96% in Sardjito Scoring System .

We can conclude that Sardjito Scoring System of open fractures is valid and reliable. Its sensitivity, specificity, accuracy, positive predictive value and negative predictive value are 98.31%, 81.10%, 86.56%, 70.73% and 99.04% respectively.

However the results of the study is surprisingly high. It is still too early to state that the system is applicable. We know very well if the incidence of open lower limb fractures is the highest among all open fractures of other extremities, but we cannot underestimate them. It would be better for us to wait for study of the Sardjito Scoring System after it is applied to other open fractures involving other extremities.

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