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## **Amit Jain's surgical scoring system and its ability in predicting the major amputation in diabetic foot complications**

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**Abstract**---There are numerous scoring system used in different parts of the world and most of them are for diabetic foot ulcers only with Amit Jain's surgical scoring system being the first such scoring for diabetic foot complications. This study aims to validate the Amit Jain's scoring system in predicting the risk of major amputation in diabetic foot complications. A retrospective analysis was done in Department of General Surgery of Raja Rajeswari medical college, Bengaluru, India. The study period was from January 2018 to December 2019. All the patients who underwent surgeries for diabetic foot complications in our department were included in the study. A total of 47 patients were included in this study. Majority of patients (76.6%) were males 61.7% of patients had diabetes mellitus of less than 10 years duration. Abscess was the most common pathological lesion seen in the foot affecting 36.17%. Most of the patients (59.6%) with diabetic foot complications had Amit Jain's surgical score of 6-10 and were in low risk category. 12 patients (25.5%) underwent major amputation in this study and a significant association ( $P < 0.001$ ) was noted between Amit Jain's surgical scoring and major amputation. The mean average AJ score for patients who underwent major amputation was  $20.50 \pm 4.10$ . The Amit Jain's surgical score of more than 16 had 100% sensitivity and 91% specificity and was significantly associated with major amputation ( $P < 0.001$ ) with an AUC of 0.98. This revalidation study on Amit Jain surgical scoring for diabetic foot

complications suggests that this scoring system is an excellent scoring tool for predicting risk of major amputation in complicated diabetic foot.

**Keywords**---diabetic foot, amputation, amit jain, scoring, abscess.

## Introduction

Diabetes is a major health problem that affects around 5-10% of adults in the world and it is associated with numerous complications.<sup>1, 2</sup> It is estimated that in 2017, there were 425 million people with diabetes.<sup>3</sup> One known serious complication of diabetes is the Diabetic Foot which is associated with increased morbidity and mortality.<sup>4</sup> The Global prevalence of this condition is around 6.3%.<sup>5</sup> It is stated that 15% of diabetic patients are likely to have foot ulcer during their life span.<sup>6, 7</sup> The annual incidence of ulcer in foot is around 2-6%.<sup>7, 8, 9</sup> There are studies that show that around 85% of all amputation done in diabetes patient was preceded by an ulcer in the foot.<sup>10</sup> There are numerous classifications for diabetic foot ulcers that include Wagners- Meggit classification, SAD, SINBAD, Amit Jain's Diabetic foot ulcer classification, etc.<sup>11, 12, 13</sup>

There are numerous scoring systems in diabetic foot and they include DEPA scoring, MAID score, Saint Elian wound score system, etc.<sup>11, 12</sup> It is well known that there is difference between a classification which is usually descriptive and a scoring system which gives an idea of severity.<sup>12</sup> One can see from above that most of them are meant for diabetic foot ulcers, which is a focal entity in the entire spectrum of diabetic foot complications. Recently, a new scoring system was proposed from India for diabetic foot complications.<sup>14, 15</sup> The Amit Jain surgical scoring system (Table 1) predicts the link of major amputation in diabetic foot and is first such scoring system on diabetic foot from India.<sup>14, 15, 16</sup> This study aims to revalidate this surgical score for diabetic foot complications.

Table 1  
Amit Jain's (AJ) surgical scoring system for diabetic foot complication

Sl No	Characteristics	Involvement Of Foot			
		No Ulcer → 0	Forefoot Ulcer → 2	Midfoot Ulcer → 4	Hindfoot Ulcer/ Full Foot/Beyond → 6
1]	Presence Of Ulcer	No O.M → 0	Forefoot O.M → 2	Midfoot O.M → 4	Hindfoot O.M → 6
2]	Osteomyelitis [O.M]	No Pus → 0	Forefoot Pus/Dorsum → 2	Midfoot Pus → 4	Hindfoot Pus/Beyond It → 6
3]	Presence Of Pus	No Gangrene → 0	Forefoot Gangrene → 2	Midfoot Gangrene → 4	Hindfoot Gangrene/Beyond → 8
4]	Gangrene [Dry/Wet]	No P.A.D → 0	Mild → 2	Moderate → 4	Severe → 8
5]	Peripheral Arterial Disease	No → 0	Forefoot → 2	Midfoot → 4	Hindfoot/Whole
6]	Charcot Foot/				

	Destroyed Joints				Foot → 8
7]	Necrosis [Skin]	No → 0	Forefoot Necrosis → 2	Midfoot Necrosis → 4	Hindfoot Necrosis/Beyond → 8
8]	Associated Cellulitis	No → 0	Upto Forefoot → 2	Upto Midfoot → 4	Upto Hindfoot & Beyond → 6
9]	Previous Amputation	No → 0	Toe Amputation → 2	Forefoot Amputation → 4	Midfoot Amputation → 6
10]	Presence Of Gas – Radiologically	No → 0	Gas In Forefoot → 1	Gas In/Upto Midfoot → 2	Gas In/Upto Hindfoot → 3
11]	Myonecrosis	No → 0	Myonecrosis Involving Single Muscle Group → 2	Myonecrosis Involving More Than One Group → 4	Myonecrosis Of Entire Foot Muscle With Extension To Leg → 8
12]	Joint Involvement	No → 0	Forefoot Joint Exposure → 2	Midfoot Joint Exposure → 4	Hindfoot Joint Exposure → 6
13]	Septic Shock	No → 0		Present → 2	
14]	Renal Failure [Acute]	No → 0		Present → 2	
15]	Smoking [Heavy Smoker]	No → 0		Present → 2	
16]	Surgeon Factor	Podiatric/Diabetic Foot Surgeon → 0		Other Surgeons → 2	

## Methods and Materials

A descriptive retrospective analysis was done in Department of General Surgery of RajaRajeswari medical college, Bengaluru, India. This is a tertiary care teaching hospital that predominantly caters rural population. The study was approved by IEC (RRMCH-IEC/17/2020-21). The study period was from January 2018 to December 2019. The Inpatient case records, OT register and discharge summaries were used to collect the data. The following were the inclusion and exclusion criteria

### Inclusion criteria

All patients who underwent surgeries for diabetic foot in department of surgery.

### Exclusion criteria

- Patients who were discharged against medical advice
- Patients treated in other departments
- Charts with insufficient data

- Patients with road traffic accident and malignancy
- Patients with foot sparing lesions (affecting leg and thigh only)

### Statistical analysis

Descriptive statistics are reported using mean and SD for the normally distributed continuous variables, for the variables that are not normally distributed were median with 25<sup>th</sup> and 75<sup>th</sup> percentiles. Categorical variables were reported as number and percentage. Independent t test or Mann Whitney U test was used to find the significance of AJ scoring between two groups. Kruskal Wallis test was used to compare the AJ score by diagnosis and type of surgery. Chi-square/ Fisher Exact test was used to find the association of major amputation done with clinical parameters. The discriminative power of the prediction of score was assessed by calculating the area under the receiver operating characteristic (ROC) curves (AUC). Sensitivity, specificity, positive predictive and negative predictive values were reported. P value less than 0.05 was considered statistically significant. All the analysis was performed using SPSS version 25.0 (IBM Corp-2017, Armonk, NY).

### Results

A total of 47 patients who fulfilled the inclusion criteria were studied. Around 48.9% of patients were less than 60 years of age. Majority of patients (76.6%) were males and left foot (57.4%) was most commonly involved. 38.3% of patients had diabetes mellitus of more than 10 years duration. 34% of them had underlying comorbidities with 23.4% having hypertension and 10.6% having ischemic heart disease. Abscess was the most common pathological lesion seen affecting 36.17% and toe amputation (46.81%) was the most common surgical procedure done. Only 2.1% had past amputation. 12 patients (25.5%) underwent major amputation in this study. Most of the patients (59.6%) with diabetic foot complications had Amit Jain's surgical score of 6-10 and were in low-risk category. 25.5% of patients had a score of 16-20 and were in high-risk category for major amputation (Table 2).

Table 2  
Showing the clinical and demographic profile

Variables	Number	Percentage
Age (in years)		
< 60	23	48.9
>60	24	51.1
Sex		
Male	36	76.6
Female	11	23.4
Side of foot involved		
Right	20	42.6
Left	27	57.4
Duration of diabetes mellitus		

<10 years	29	61.7
>10 years	18	38.3
Co-morbidities		
Yes	16	34
No	31	66
Hypertension		
Yes	11	23.4
No	36	76.6
IHD		
Yes	5	10.6
No	42	89.4
Diagnosis		
Abscess	17	36.17
Gangrene	13	27.66
Infected ulcer	12	25.53
Necrotizing fasciitis	5	10.64
Surgery		
Debridement	10	21.28
Toe amputation	22	46.81
Trans-metatarsal	3	6.38
Below knee amputation	11	23.40
Above Knee amputation	1	2.1
Past amputations		
Yes	1	2.1
No	46	97.9
Major Amputation		
Yes	12	25.5
No	35	74.5
Amit Jain's Surgical Scoring (AJ score)		
<5 (very low risk)	1	2.1
6-10 (Low risk)	28	59.6
11-15 (moderate risk)	3	6.4
16-20 (High risk)	12	25.5
21-25 (Very high risk)	1	2.1
>26 (amputation inevitable)	2	4.3

Table 3 shows the association of clinical variables and mean Amit Jain's scoring system. There was no significant association of age, sex, duration of diabetes, side of foot involved and comorbidities with AJ scoring. Significant association ( $P < 0.001$ ) was noted between Amit Jain's surgical scoring and major amputation. The mean average AJ score for patients who underwent major amputation was  $20.50 \pm 4.10$ . An association was also seen between diagnosis and AJ scoring. Patients with necrotizing fasciitis had highest mean score ( $18 \pm 3.464$ ) followed by gangrene ( $P = 0.043$ , significant). Patients with above knee amputation had a score

of 26 whereas those with below knee amputation had a mean score of  $20 \pm 3.899$  and it was significant ( $P < 0.001$ ).

Table 3  
Showing association of clinical variables with mean AJ score

Variables	Number	Mean AJ Score ( $\pm$ SD)	P value
Age (Years)			
<60	23	$9.91 \pm 6.045$	0.117
>60	24	$12.83 \pm 6.458$	
Sex			
Male	36	$11.78 \pm 6.481$	0.473
Female	11	$10.18 \pm 6.096$	
Duration of Diabetes mellitus (Years)			
<10	29	$10.76 \pm 5.514$	0.383
>10	18	$12.44 \pm 7.594$	
Side of the foot			
Left	20	$13.40 \pm 7.870$	0.064
Right	27	$9.93 \pm 4.590$	
Co-morbidities			
Yes	16	$11.25 \pm 6.962$	0.907
No	31	$11.48 \pm 6.153$	
Major amputation			
Yes	12	$20.50 \pm 4.101$	<0.001
No	35	$8.29 \pm 3.186$	
Diagnosis			
Abscess	17	$9.76 \pm 5.739$	0.043
Gangrene	13	$12.62 \pm 8.016$	
Infected ulcer	12	$9.67 \pm 4.25$	
Necrotizing fasciitis	5	$18 \pm 3.464$	
Surgery			
Debridement	10	$9 \pm 4.738$	<0.001
Toe amputation	22	$8.18 \pm 2.462$	
Transmetatarsal	3	$6.67 \pm 1.155$	
Below knee amputation	11	$20 \pm 3.899$	
Above Knee amputation	1	26	

No association was seen among age, sex, duration of diabetes mellitus and co morbidities with major amputation. Majority of patients who had major amputation belonged to high-risk category (75%) followed by inevitable amputation category (16.7%) and it was statistically significant ( $P < 0.001$ ). Patients with score of less than 15 did not have major amputation in this study (Table 4).

Table 4  
Showing association of clinical variables with major amputation

Variables	Major Amputation		P Value
	Yes	No	
Age			
<60	5 (41.7%)	18 (51.4%)	0.740
>60	7 (58.3%)	17 (48.6%)	
Sex			
Male	9 (75%)	27 (77.1%)	1.000
Female	3 (25%)	8 (22.9%)	
Duration of diabetes mellitus			
<10	6 (50%)	23 (65.7%)	0.493
>10	6 (50%)	12 (34.3%)	
Co morbidities			
Yes	4 (33.3%)	12 (34.3%)	1.000
No	8 (66.7%)	23 (65.7%)	
AJ surgical score			
<5 (Very low risk)	0 (0%)	1 (2.9%)	<0.001
6-10 (Low risk)	0 (0%)	28 (80%)	
11-15 (Moderate)	0 (0%)	3 (8.6%)	
16-20 (High)	9 (75%)	3 (8.6%)	
21-25 (Very high)	1 (8.3%)	0 (0%)	
>26 (amputation inevitable)	2 (16.7%)	0 (0%)	

Figure 1 shows the box plot of Amit Jain's surgical scoring and major amputation. Table 5 shows the sensitivity, specificity, positive predictive and negative predictive values. It can be seen that patients with AJ score of more than 16 had 100% sensitivity and 91% specificity and was significantly associated with major amputation ( $P < 0.001$ ) with an AUC of 0.98 (Figure 2). The model quality was assessed using ROC analysis, showed that the AJ surgical scoring achieved good model quality of 96% (Figure 3). There was no inpatient mortality in this series.

Table 5  
Showing the sensitivity and specificity of AJ surgical score

AJ score	Sensitivity (CI)	Specificity	PPV	NPV	P value
11 and above	100	83	67	100	<b>0.03</b>
16 and above	100	91	80	100	<b>&lt;0.001</b>

## Discussion

Amputation of the limb is one of the most ancient surgical procedure with more than 2500 years of history and it was first described in 460 - 377 BC by Hippocrates.<sup>17, 18</sup> Amputations are considered to be disfiguring surgery and it is associated with social, economic and psychological effects on patients and their families.<sup>17, 19</sup> In today's era, diabetes is the most common cause for non-traumatic

amputation and it is seen that individual with diabetes are in 30 - 40 times higher risk for amputations compared to non-diabetics.<sup>20, 21</sup> Amputations done above ankle joint are considered to be major amputations and those distal to ankle are minor amputations.<sup>21, 22</sup> Amputations, major or minor, are associated with high morbidity and mortality.<sup>17, 22</sup> Major amputations like below knee had 30.4% of morbidity and 7% of 30 day mortality rate postoperatively.<sup>23</sup> It was observed that 80% of patients with minor amputations were alive even after 2 years. Whereas, 52% of patients with major amputation (Below Knee) died within 2 years.<sup>24</sup> Such are the disastrous outcome of amputations. Adding to this burden is stump complications and re-amputations.

Numerous scoring systems exist & most of them focus on diabetic foot ulcer mainly. Amit Jain scoring system for diabetic foot complications is a newly formulated surgical scoring system proposed in 2014 from India.<sup>15, 16, 25</sup> The Amit Jain's surgical scoring system for diabetic foot complications has 16 parameters.<sup>15</sup> This scoring system uniquely consists of anatomical, clinical, surgical and radiological factors that are scored. In a previous study by Jain et al<sup>16</sup>, more than 80% of patient who underwent major amputation had AJ score of 16 & above. In Kalaivani et al series done on diabetic foot amputees, around 85% of patients who underwent major amputations had score of more than 16.<sup>25</sup> It was noticed that with increasing score, there were more major amputations<sup>16</sup> and also, there was significant associated stump complications.<sup>22</sup>

In another validation study by Jain et al on trans-metatarsal amputations in diabetic foot, it was observed that, in patient who had trans-metatarsal amputation, those with score 16 and above, significantly underwent major amputation<sup>11</sup> and also re-surgeries.<sup>14</sup> In this study that is aimed at revalidating the score in diabetic foot complication in rural patients, it was noted that patient with AJ score of more than 16 was significantly associated ( $P < 0.001$ ) with major amputations with 100% sensitivity and 91% specificity with area under curve for AJ surgical score being 0.98 and this is considered to be excellent in predicting major amputation in diabetic foot. Our study also showed that patient with necrotizing fasciitis & above knee amputation had significantly higher AJ surgical score.

## **Conclusion**

Diabetic foot complications, if presented late, are associated with amputation. Patients who had AJ score of 16 and above were at increased risk of major amputation. This validation study on Amit Jain surgical scoring system suggests it to be an excellent scoring tool for predicting risk of major amputation for diabetic foot complications.

## **Acknowledgment**

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**Figures**

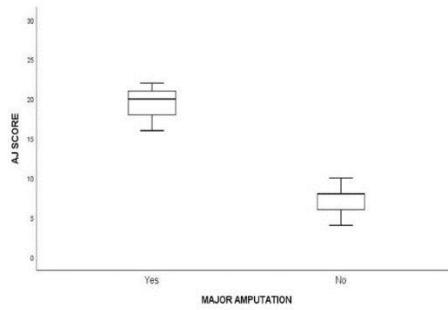


Figure 1. Showing the box plot

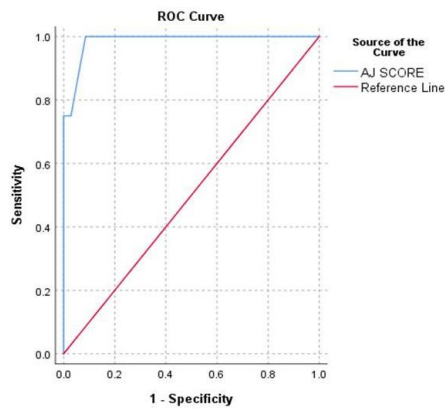
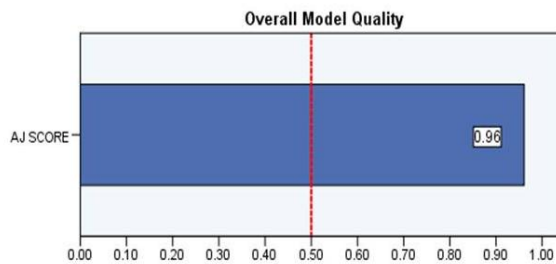


Figure 2. Showing the receiver operating curve (AUC of 0.98)



**A good model has a value above 0.5**  
**A value less than 0.5 indicates the model is no better than random prediction**

Figure 3. Showing the good model quality of the Amit Jain’s surgical scoring

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