

Research Article

Lahore Wheel Spoke Injury Classification

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Abstract

Background: Pakistan has seen an increase in wheel spoke injuries of the foot as motorcycles become a more popular mode of transportation. The resulting injuries can range from minor abrasions to mangled feet that need to be amputated. Currently, there is no comprehensive classification that can categorize the wide range of injuries that have been observed.

Objective: This study aims to critically evaluate the classifications used to describe wheel spoke injuries and define the subtypes that these classifications did not cater for. As a result, the Lahore Classification, a new classification for wheel spoke injuries, is being proposed, along with management for each subtype.

Methodology: Retrospective study of a total 156 wheel spoke injuries of foot was undertaken to categorize/classify these injuries in terms of injured structures. Wheel spoke injury patients of all ages and both genders; evaluated and admitted in Jinnah Burn & reconstructive surgery Centre (JB&RSC), Jinnah hospital/AIMC, Lahore, Pakistan were included in this study from January 2019 to December 2023.

Results: A total of 156 “Wheel Spoke Injury” patients involving feet presented to our department. Injury mechanism and structures involved were noted. There were 42 patients who did not fit in specific grades of the existing classifications. A modification in the existing classification for the wheel spoke injury was devised and management of different subtypes was undertaken. The proposed algorithm for management ranges from conservative care to the need for free flap to cover the defect.

Conclusion: Wheel spoke injuries of the foot can be managed more effectively with the help of a practical grading system. We propose a revised classification that will guide the management plan and a treatment algorithm which will ultimately improve the patient's outcome.

Received | 24-04-2024 **Revision** | 26-06-2024 **Accepted** | 01-07-2024

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Keywords | Wheel Spoke Injury; Lahore; Classification; Achilles Tendon; Calcaneal Fracture; Calcaneum; Tibial Nerve; Neurovascular Bundle; Flap coverage; Soft tissue; Skin graft; Sural Flap; Free flap; Foot; Heel; Ankle; Treatment Algorithm.

Introduction

Injuries requiring reconstruction are on the rise due to popularity of motor bikes as mode of transportation in Pakistan especially in crowded urban areas.¹ One of the injuries related to bike pillion riding is wheel spoke injury, which is caused by foot entrapment in the rotating spokes of bicycle or motorbike. Wheel spoke injuries

sustained on motor bike are more severe due to higher momentum as compared to a bicycle.

In most cases foot is entrapped in rear wheel causing eversion and injury to weight bearing area (heel/ankle). While front wheel injury mainly causes inversion, with laceration over dorsum and medial aspect of the foot.² These injuries can vary from simple abrasion to a mangled

foot causing great morbidity to its victim. This injury also poses a great challenge to the health care provider. Long hospital stays and multiple surgeries is the fate of most of these injuries.

Since the first reported case of wheel spoke injury³ many articles have been published about this injury. Authors have used various classifications to describe their findings. Some used Oestern and Tscherne soft tissue injury classification,^{4,11} some modified soft tissue injury classification to better describe wheel spoke injury^{12,13} and others used description of soft tissue injury with fractures classifications to classify the injuries.¹⁴⁻¹⁷

We routinely used classification for wheel spoke injury proposed by Yue-Liang Zhu et al¹⁴, to grade severity of such injuries in our practice. But soon we realized the deficiency of this classification and the other classifications to completely describe the injury. The injury of Neurovascular bundle (NVB), which is not that infrequently seen in these patients and injury to foot other than heel/Ankle area is not included in most of the classifications.^{12,14,15,16,17}

Since each wheel spoke injury is unique, we have devised a modified classification system that will help describe and evaluate these injuries better so that their effective management can be undertaken.

Methodology

We reviewed medical records of 156 wheel spoke injury patients which were referred to the Plastic Surgery unit by the A&E department of Jinnah hospital/AIMC, Lahore between January 2019 and December 2023.

In each case patient's history and primary assessment was undertaken. X-rays of the affected foot were taken. Final findings were noted per operatively.

Each patient was classified according to the known classifications.^{12,14,15,16,17} Short comings in the currently used classifications were noted. A modified classification was devised. Surgical management of each patient was undertaken according to the assigned grade.

The work was approved by the ethical committee of the specialized tertiary health care facility affiliated with Allama Iqbal Medical College.

Results

The total number of patients who presented with wheel spoke injury from January 2019 to December 2023 was 156. In 144 (92.31%) cases heel/ankle area was involved and in 12 (7.69%) cases other areas of foot

were involved (Mostly Dorsum). (Figure 1).



Figure 1: Anatomical location of injury

Out of total 156 patients 111 (71.15%) were male and 45 (28.84%) were female. Right foot was involved in 96 (61.54%) and left foot was involved in 60 (38.46%) cases (Table 1).

Table 1: Gender Distribution and Involved foot

Total Patients	Sex		Foot	
	M	F	Rt	Lt
156	111	45	96	60
	71.15%	28.84%	61.54%	38.46%

Table 2: Proposed Classification

Lahore Wheel Spoke Injury Classification	
Grade 0	
<ul style="list-style-type: none"> • Abrasion or Laceration with or without Partial thickness skin loss • No injury / exposure of Achilles tendon or Bone or Neurovascular bundle 	
Grade 1	
<ul style="list-style-type: none"> • Skin Defect with Exposed Achilles tendon Or Bone/Calcaneum 	
Grade 2	
2A	
<ul style="list-style-type: none"> • Skin defect with Achilles tendon Rupture/Defect 	
2B	
<ul style="list-style-type: none"> • Skin defect with Achilles tendon Rupture/ Defect + Injury to Neurovascular bundle 	
Grade 3	
3A	
<ul style="list-style-type: none"> • Skin Defect with Bone/Calcaneal Fracture with or without Achilles tendon rupture/defect 	
3B	
<ul style="list-style-type: none"> • Skin defect with Bone/Calcaneum Fracture with or without Achilles tendon Rupture + Injury to Neurovascular bundle 	
Grade 4	
<ul style="list-style-type: none"> • Mangled Heel (Comminuted Fracture of Bone/Calcaneum + Achilles Tendon Rupture/Defect+ Injury to Neurovascular bundle+ Skin Defect) 	
Grade 5	
<ul style="list-style-type: none"> • Injury of foot other than Heel/Ankle area with or without bony injury 	

At first, we graded our patients according to the classification proposed by Yue-Liang Zhu et al.¹⁴ After catego-

riking the patients, we were still left with 42 patients, who would not fit into any of the grades of the above-mentioned classification. The patients who did not fit in the classification were the ones with injury to the NVB, the patients with injury to foot other than heel/ankle area and the patients without significant soft tissue loss, but still needed special consideration as their grade might change after initial debridement.

Lahore Wheel Spoke Injury Classification is proposed so that it can describe and categorize the patients who did not fit in the above mentioned classification before. (Table 2).

According to the modified classification, total included patients i.e., 156 patients were graded as follows. 6 patients of Grade 0, 54 patients of Grade 1, 18 patients of Grade 2A, 12 Patients of Grade 2B, 39 patients of Grade 3A, 12 patients of Grade 3B, 3 patient of Grade 4 and 12 patients of grade 5.

Initial presentation of the wheel spoke injury can be misleading because some of the injuries that seem minor (Grade 0) on the first evaluation, their grades change after EUA and debridement. In our experience, there were 15 cases initially labeled as Grade 0, of which only 6 remained true Grade 0, the rest, i.e., 9 cases, changed to Grade 1 after debridement, and the total number of Grade 1 cases increased from 45 to 54.

In Figure 2, the number of cases and the percentages of various grades for 156 patients are displayed.

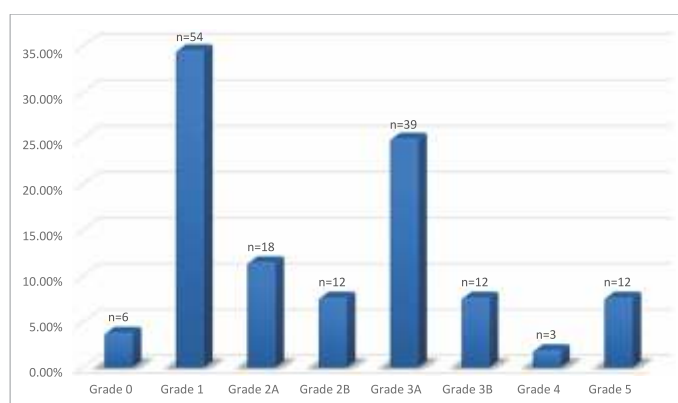


Figure 2: Number of cases and percentage of assigned grades according to Lahore Wheel Spoke Injury Classification.

Discussion:

Wheel spoke injury was first reported in 1948³. Many articles about the wheel spoke injury have been published since then. Some reported its incidence and others were

to classify, treat and suggest prevention from the wheel spoke injury⁴⁻¹⁸. Its incidence was first reported in Pakistan by Dr Mushtaq Ahmed of Dow Medical College, Karachi, Pakistan. He reported 21 cases of wheel spoke from October 1976 to February 1978. He described the injuries, their mechanism, treatment and suggested measures to avoid the injury.

Due to the distinct mechanism of wheel spoke injury, the spectrum of its presentation is quite vast. Authors have used various classifications to describe the wheel spoke injury starting from Oestern and Tscherne classification of soft tissue injury^{4,5,6,7,8,9,10,11} to the modifications of the Oestern and Tscherne classification^{12,13}.

Oestern and Tscherne classification of soft tissue injury^{19,20} roughly covers all the aspects of injury but cannot describe the injury precisely. Its modifications^{12,13} lack the description of minimal injury, injury to NVB or dorsum of foot which is seen every now and then in these patients.

We routinely used wheel spoke injury classification, proposed by Yue-Liang Zhu et al¹⁴, to grade severity of such injuries in our practice. We reviewed our data from January 2019 to December 2023 and noted that 42 (26.92%) of 156 patients did not fit into any of the grades of the above-mentioned classification.

The patients who did not fit into this classification¹⁴ were the ones with injury to the NVB i.e., 2B & 3B or patients with minimal injury i.e., True Grade 0 (6 of 15) who remained Grade 0 after EUA and debridement or the ones with injury to the dorsum of foot (Grade 5). In light of our findings, we modified the classification¹⁴ in use to categorize the injuries that were not graded by it. (Figure 3).

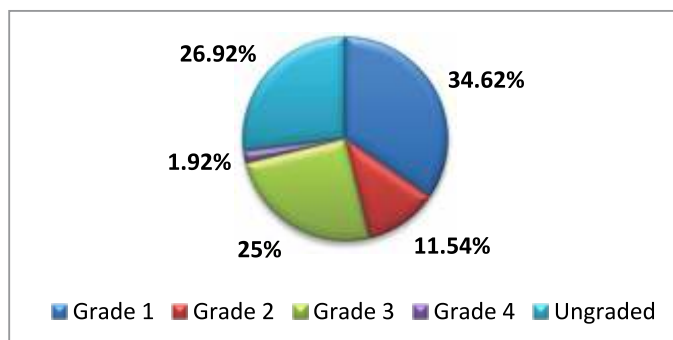


Figure 3: Grades according to previously used classification

It was concluded that all findings related to the wheel spoke injury cannot be summarized by any single existing classification, so Lahore Classification was devised.

The included 156 patients were then graded according to the Lahore Classification as follows. 6 patients of Grade 0, 54 patients of Grade 1, 18 patients of Grade 2A, 12 Patients of Grade 2B, 39 patients of Grade 3A, 12 patients of Grade 3B, 3 patient of Grade 4 and 12 patients of grade 5. The percentages of different grades in 156 patients were; Grade 0 (3.85%), Grade 1 (34.62%), Grade 2A (11.54%), Grade 2B (7.69%), Grade 3A (25%), Grade 3B (7.69%), Grade 4 (1.92%) and Grade 5 (7.69%). (Figure 4).

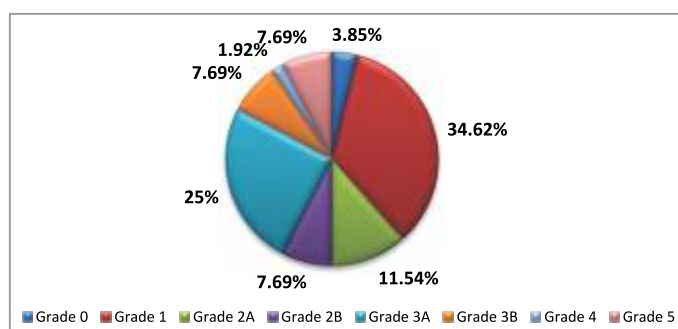


Figure 4: Grades according to Lahore Classification

It was also noted that most of the injured patients were males of age between 3-12 years and they mostly belong

All patients underwent EUA and debridement. Findings were noted and injuries were graded. 9 of the original 15 Grade 0 injuries were converted to Grade 1 surgically because most of the times the underlying injury is much greater than the outer look of the wound. The bruised and lacerated skin/subcutaneous tissue does not always survive due to the crushing/cutting mechanism of the wheel spoke injury. Daily dressing along with intermittent VAC dressing was done where needed. Some cases required multiple debridements which were done according to the need. Once the grades were finalized, we discussed the cases and laid out plan for surgical treatment for each case according to its need. (Table 3)

Grade 0 injuries (Figure 5A-5C) whose grade did not increase after initial debridement were treated with dressings, delayed primary closure or split thickness skin graft (STSG) where needed.

Grade 1 injuries (Figure 6A-6E) with exposed tendon/bone were treated by skin grafting (on intact paratenon), coverage with artificial dermis + STSG (if wound bed was found suitable) and with local flaps accordingly.

Grade 2A injuries (Figure 7A-7D) which included lacerated/defected Achilles tendon and soft tissue loss

Table 3: Treatment Algorithm*

Wheel Spoke Injury							
Primary assesment according to ATLS protocol and provisional grading							
Examination Under Anesthesia							
Grade 0	Grade 1	Grade 2A	Grade 2B	Grade 3A	Grade 3B	Grade 4	Grade 5
Dressings Or Delayed primary closure or Skin graft where needed.	STSG (on intact paratenon) or Coverage with artificial dermis + STSG (if wound bed was found suitable) or Coverage with local flaps.	Repair / Grafting of tendon + Local flap coverage	Repair / Grafting of NVB, + Repair / Grafting of tendon + Flap coverage (Local/Free)	Bony fixation + Repair / Grafting of the tendon + Flap coverage (Local/Free)	Bony fixation + Repair / Grafting of tendon + Free flap coverage	Amputation	STSG/ Flap Coverage (Local/Free) + Bony Fixation where needed

* Bony fractures were treated (fixation or conservative management) by the Orthopedic department.

ged to grades 1 and 3A.

The patients were initially assessed in the A&E department of the Jinnah Hospital/AIMC, Lahore, Pakistan. Following ATLS and primary care, the evaluation included patient's history, a comprehensive physical examination, and an examination of the injured leg or foot. The wounds were then washed and temporary dressing was applied. X-ray of the injured foot was taken to evaluate the bone status. The patients were then admitted in Jinnah Burn & Reconstructive surgery center, Jinnah Hospital, Lahore for management.

were treated by repair/grafting of tendon with local flap coverage.

Grade 2B patients (Figure 8A-8D) were with injured NVB, lacerated/defected Achilles tendon and soft tissue loss. They were treated by repair/grafting of NVB, repair/grafting of tendon with flap coverage (mostly free).

Grade 3A patients (Figure 9A-9E) were with defected skin and bone/calcaneal fracture with or without Achilles tendon rupture/defect. They were treated by bony fixation (by orthopedic department), repair/grafting of the

tendon and coverage with local flaps.

Grade 3B (Figure 10A-10F) included patients with skin defect, fracture of bone/calcaneum, ruptured Achilles tendon and injured NVB. They were treated by bony fixation, repair/grafting of NVB, repair/grafting of tendon and coverage with flaps (Mostly free).

The fate of **Grade 4** (Figure 11A-11D) mangled feet was amputation.

Grade 5 Patients (Figure 12A-12C) were treated with STSG with or without artificial dermal matrix or flap coverage with bony fixation where needed.



Figure 5: 26 years old male with **Grade 0** Injury of left foot (A). After EUA it remained Grade 0 and was treated with delayed primary closure (B). 3rd Post Op Day (C).



Figure 6: 10 years old male with **Grade 1** injury of left foot (A). After debridement calcaneum was exposed (B). He was treated with application of artificial dermis (C) and a thin split thickness skin graft (D). 8th Post Op Day (E).



Figure 7: 12 years old male with **Grade 2A** injury to right foot with ruptured Achilles tendon(A, B). He was treated with tendon repair with graft (C) and coverage of wound with Adipofascial Sural flap and STSG (D).

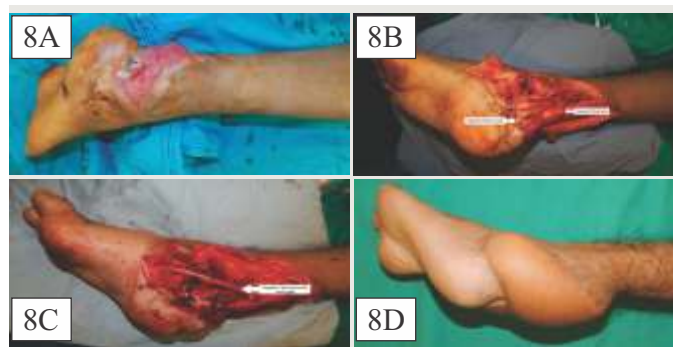


Figure 8: 17 years old male with **Grade 2B** injury with transected Tibial nerve and Achilles tendon (A). He was treated with Achilles tendon repair (B) and cable nerve graft for Tibial nerve (C). Wound coverage was done with free Scapular Parascapular flap (D).



Figure 9: 6 years old female with **Grade 3A** injury to left foot (A) with chip fracture of Calcaneum (B) and a

partial tear in Achilles tendon (C). Fracture was managed conservatively; Achilles tendon was repaired and wound was covered with Adipofascial sural flap (D) & STSG (E).



Figure 10: 7 years old male with **Grade 3B** injury of right foot (A). Fracture of Calcaneum, Talus and Tibia (B) was managed by the Orthopedic department. Achilles tendon (C) and Tibial nerve (D) were repaired with grafts. Wound was covered with free Scapular Parascapular flap (E). Two months Post Op (F).



Figure 11: 24 years old male with **Grade 4** injury of left foot (11 A-D). Amputation was done by the Orthopedic department



Figure 12: 10 years old male with **Grade 5** Injury to left foot (A). After debridement (B) wound was covered with STSG (C).

Conclusion

Wheel spoke injury is a distinct entity amongst lower limb trauma and is peculiar to pillion riding. As weight bearing area; heel/ankle is most commonly involved, it causes great morbidity for the patient in terms of long hospital stay and multiple surgeries. It also poses great challenge for the reconstructive surgeon.

With motorcycle getting popular by the day as an easy affordable mode of transportation¹, the incidence of wheel spoke injury is inevitable in low to middle income countries like Pakistan. A well devised grading system to define such injuries could help manage the injuries better.

The Lahore Wheel Spoke Injury Classification is the result of a study that spanned over half a decade and included a large number of representative cases. Almost all aspects of wheel spoke injuries, including their proposed management, are covered by it.

The limitations of the study were that it was a single hospital study, which may not represent the whole population.

Multi-centered studies are recommended for the future. In addition, safety awareness campaigns and legislative measures should be established to prevent these injuries from occurring.

Conflict of interest: None

Source of funding: None

Author's Contribution:

The following authors have made significant contributions to the manuscript as under:

Dr Usman Ishaque: Author, Data collection, and Research

Dr Ata Ul Haq: Acquisition, analysis and interpretation of data

Dr Ahsan Riaz: Analysis and Technical Editing

Dr Usman Khalid: Data collection and article writing

Dr Muhammad Younas Mehrose: Technical editing and Study supervision

Dr Ahmed Tarek Emam: Scientific advisor and data analysis.

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