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Research Article

The Effects of a Direct Discharge Protocol in Children with a Bicycle Spoke Injury

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Abstract

Background: Direct discharge (DD) from the emergency department (ED) may provide an efficient treatment option for children with a bicycle spoke injury. Although DD has been widely implemented in the Netherlands, injury specific results are lacking. This study aimed to assess the effects of DD on the treatment of children (aged <12 years) with a bicycle spoke injury compared to traditional treatment.

Patients and Methods: In this retrospective cohort study, patients aged <12 years with a bicycle spoke injury treated between January 2018 and November 2020 were included. Outcomes included secondary healthcare utilization, protocol compliance, ED reattendances and hospital treatment costs. Patient-reported outcomes and primary healthcare utilization were evaluated via an online questionnaire.

Results: The pre-DD group consisted of 102 patients and the DD group of 121. DD resulted in fewer follow-up appointments (median:1, range:3) compared to pre-DD treatment (median:0, range:4). Protocol compliance by ED caregivers was 86% in pre-DD patients vs. 88% in DD patients. ED reattendances were low and comparable in both groups. DD consequently resulted in a reduction of calculated hospital treatment costs. No persistent functional limitations or shift to primary healthcare were reported.

Conclusions: In this study, treatment of children (aged <12) with a bicycle spoke injury through DD reduced secondary healthcare utilization compared to traditional treatment, with a high protocol compliance rate. DD did not increase ED reattendances or negatively affect treatment outcomes.

Keywords: Bycicle Spoke Injury; Pediatric; Trauma; Virtual Fracture Clinic; Direct Discharge; Healthcare Utilization

Abbreviations

ED: Emergency Department; NL: The Netherlands; DD: Direct Discharge; DTC: Diagnosis Treatment Combination

Introduction

Bicycle spoke injuries are common among children in nations where bicycle riding is a significant part of daily routine, such as the Netherlands (NL) [1-3]. Approximately 4000 patients aged ≤12 years visit the ED annually in NL with a bicycle spoke injury (ED) [4]. They are caused by entrapment of the heel or foot between the spokes and frame of a riding bicycle and usually occur when young children sit on the backseat of a bicycle without adequate safety measures [5]. Traditionally, children with a bicycle spoke injury were treated with cast immobilization and were scheduled for face-to-face outpatient clinic follow-up after 1 week. However, in the majority of these outpatient clinic follow-up visits, no additional intervention or treatment is performed, especially when there is no fracture or severe wound present [6]. This indicates potentially unnecessary utilization of increasingly scarce secondary healthcare resources.

In May 2019, a Direct Discharge (DD) protocol was introduced in our level 2 trauma center and teaching hospital in the NL [7]. This protocol is derived from the Virtual Fracture Clinic concept, which has been proven safe, efficient and cost-effective [8-10]. The DD protocol is used in the ED for the treatment of several simple and stable injuries, which heal without rigid immobilization, including bicycle spoke injuries. With DD, patients with a relatively mild bicycle spoke injury (e.g., no fracture or severe wounds) are directly discharged from the ED and are not scheduled for routine follow-up. They receive self-removable immobilization material and extensive information about the injury in the form of a leaflet

and a supportive smartphone application [7]. If patients require further information or care, they can contact a specific helpline or visit the outpatient clinic if required.

Positive results of DD have sparked widespread implementation throughout NL [11]. However, even though the bicycle spoke injury has been widely included in DD protocols, specific results of DD for children with such an injury have not yet been examined. Therefore, the aim of this study is to assess secondary healthcare utilization, protocol compliance and treatment outcomes in pediatric patients (aged ≤12 years) with a bicycle spoke injury treated with DD versus traditional treatment.

Materials and Methods

Study design and setting

This was a single center, retrospective cohort study comparing treatment of children (aged ≤12) with a bicycle spoke injury treated between January 2018 and November 2020, with a minimum follow-up period of one year after ED admission. It was performed in an urban, level-2 trauma center and teaching hospital NL, where DD was introduced on the 20th of May 2019. Two groups of patients were formed based on ED admission date: a pre-DD group (ED presentation before DD implementation) and a DD group (ED presentation after DD implementation).

Traditional treatment

Traditional treatment of bicycle spoke injuries consisted of plaster cast immobilization for a minimum of one week, followed by at least one routine outpatient follow-up appointment at the outpatient clinic for inspection of the soft tissues and information provision about further recovery. No routine imaging was performed.

Direct discharge

Patients treated with DD were directly discharged from the ED and received a pressure bandage for three days. Patients and their parents additionally received extensive information at the ED, summarized in a leaflet and a smartphone application. No routine follow-up appointments were scheduled. Parents were also instructed to contact the hospital via a specific phone number in case of red flags, including: signs of infection, progression of pain, function loss, and/or no reduction of pain within two weeks. All radiographs of DD patients were reviewed by a supervising trauma surgeon and radiologist the next working day. Patients who were misdiagnosed and incorrectly treated with DD were contacted to plan adequate treatment.

Recruitment and consent

Records of children aged ≤12 who presented at the ED between January 2018 and November 2020 with a foot/ankle and lower extremity related diagnosis-related group were screened for eligibility. All patients with a bicycle spoke injury who met inclusion criteria for DD were eligible for study inclusion. DD eligibility was assessed by ED caregivers at presentation. Inclusion criteria for DD were: minimal external wounds (superficial, abrasions) and no fracture on radiographic imaging. Exclusion criteria for this study were cognitive impairment, initial presentation elsewhere, multiple injuries, and follow-up in a different hospital. Additionally, caregivers of eligible patients received an online study questionnaire. The questionnaire was sent upon agreement, with a one-time reminder per e-mail after three days in case of an incomplete questionnaire. All participants provided digital consent before participation. The local ethical research committee approved this study (WO 22.190).

Data collection

The following data were retrospectively collected from patients' electronic patient records, with a minimum follow-up period of one year after patient ED admission date: ED admission date, age, sex, presence of wounds as reported by ED caregivers (none or superficial), treatment plan (pre-DD or DD, number and type of outpatient clinic follow-up appointments (face-to-face or by phone), follow-up radiographs, protocol compliance by ED caregivers and reason for deviation if applicable (if no clear clinical indication was found, deviation from protocol was attributed to unawareness of treatment protocols among ED staff), unplanned ED reattendances and reason for reattendance, and documented complications at outpatient clinic follow-up (e.g. progression and/or persistence of pain, inability to bear weight on the injured foot after one week and wound infection).

An online questionnaire was used to collect data on patient satisfaction with treatment, measured as a score on an ascending scale from 0-100 (with 100 being extremely satisfied), functional outcomes (persistent limitation in function) and the number of visits to the general physician or physiotherapist (Appendix 1).

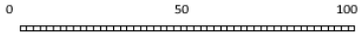
Appendix 1

Questionnaire - patient experience following bicycle spoke injury.

Some time ago, your child was treated at OLVG due to a spoke injury. With the help of this questionnaire, we would like to know from you how you have experienced the recovery and/or hospital visit(s) and what the quality of care has been.

How satisfied are you with the overall treatment your child received at OLVG?

0 = Completely dissatisfied – 100 = Completely satisfied



Can your child use the ankle and/or foot as well as before your child got injured?

- Same as before
- Well, but slightly less than before
- Use of the ankle and/or foot is limited
- Use of the ankle and/or foot is barely possible.

Is your child limited by the injury in daily functioning?

- No
- Sometimes (1-2 times a week)
- Often (3-5 times a week)
- On a daily basis (every day).

Is your child limited by the injury during sports activities?

- No
- Sometimes (1-2 times a week)
- Often (3-5 times a week)
- On a daily basis (every day).

Is your child limited by the injury during school activities?

- No
- Sometimes (1-2 times a week)
- Often (3-5 times a week)
- On a daily basis (every day).

Did you and/or your child visit your general practitioner because of the spoke injury?

- No
- Yes, once
- Yes, twice
- Yes, more than twice.

Did you and/or your child visit a physiotherapist because of the spoke injury?

- No
- Yes, once
- Yes, twice
- Yes, more than twice.

Appendix 1: Questionnaire - patient experience following bicycle spoke injury.

Outcomes

The primary outcome measure was secondary healthcare utilization, measured by the total number of outpatient clinic follow-up appointments and follow-up radiographic imaging of the injured leg.

Secondary outcomes included protocol compliance by ED caregivers, unplanned hospital reattendances, documented complications at outpatient clinic follow-up (e.g., progression and/or persistence of pain, inability to bear weight on the injured foot after one week and wound infection), and calculated hospital treatment costs, including diagnosis treatment combination (DTC) costs and costs of utilized secondary healthcare resources.

In the Dutch healthcare system, a DTC represents total treatment costs declared by the hospital at health insurance companies for each patient after completion of treatment.[12] Costs of utilized secondary healthcare resources were based on their fixed price in NL. This was $75,92 per follow-up appointment and $40.83 per radiograph [13,14].

Additionally, patient-reported outcomes including satisfaction with treatment, persistent functional limitations, and primary healthcare utilization (visits to the general physician or physiotherapist) were analyzed.

Statistical analysis

Statistical analysis was performed using IBM SPSS Version 27.0 (IBM Corp, Armonk, New York, USA) [15]. Descriptive data of continuous variables were summarized using the appropriate measures of central tendency (i.e., mean, median) and dispersion (i.e., standard deviation, interquartile range), depending on whether the variable was normally distributed. Categorical variables were presented using frequency measures. Significance of associations between categorical variables was analyzed using the Pearson chi-square test or Fisher's exact test. For numerical variables, an unpaired T-test or one-ANOVA test was used for variables with a normal distribution, and the Mann-Whitney test or Kruskal-Wallis test was used for variables with abnormal distribution. A p-value of <0.05 indicated a statistically significant relation between variables. Missing data were not imputed and therefore excluded from analysis.

Results and Discussion

Results

After screening (n = 718), 223 (31%) patients met inclusion criteria (Figure 1).

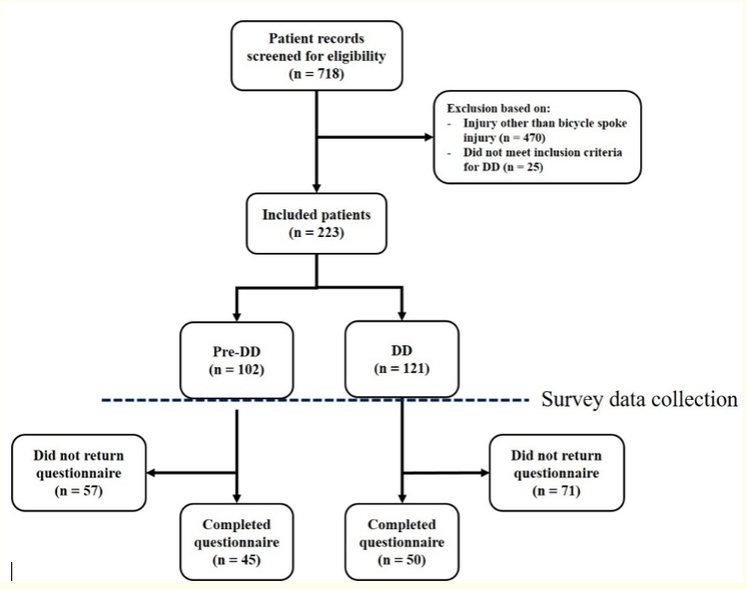


Figure 1: Flowchart of patient inclusion and questionnaire respondents.
DD: Direct Discharge

The pre-DD group consisted of 102 (46%) patients vs. 121 (54%) in the DD group. Both groups were comparable at baseline (Table 1).

Variables	Pre-DD (n = 102)	DD (n = 121)	p-value
Age; median (range)	5 (10)	5 (10)	0.95
Sex; n (%)			
Male	51 (50)	62 (51)	0.85
Female	51 (50)	59 (49)	
Wound; n (%)			
No wound	16 (16)	24 (18)	0.42
Superficial wound	86 (84)	97 (82)	

Table 1: Baseline characteristics of pre-DD and DD patients.
DD: Direct Discharge

The number of total follow-up appointments was lower in the DD group compared to the pre-DD group (Table 2). In total, 80 (78%) patients in the pre-DD group had one or more outpatient clinic follow-up appointments, versus 15 (12%) patients in the DD group. One patient in the DD group had four follow-up appointments at the outpatient clinic due to continued inability to bear weight and prolonged treatment with a softcast for three weeks, after which full recovery was achieved. An equally low number of one follow-up radiograph was performed in both groups.

Overall, protocol compliance was high and comparable between groups (Table 2).

Outcomes	Pre-DD (n = 102)	DD (n = 121)	p-value
Total follow-up appointments; median (range)	1 (3)	0 (4)	<0.001
Follow-up appointments per patient; n (%)			<0.001
0	22 (22)	106 (88)	
1	66 (65)	12 (10)	
2	10 (10)	2 (2)	
3	4 (4)	0 (0)	
4	0 (0)	1 (1)	
Follow-up radiograph; n (%)	1 (1)	1 (1)	0.90
Compliance to protocol; n (%)			0.37
Yes*	86 (84)	107 (88)	
No	16 (16)	14 (12)	
Unplanned reattendance; n (%)			
By phone	0 (0)	1 (1)	1.00
ED	0 (0)	2 (2)	0.50

Table 2: Secondary healthcare utilization in pre-DD and DD patients.

*For pre-DD patients: scheduling of a minimum of one routine follow-up appointment at the outpatient clinic one week after ED admission. For DD patients: Direct discharge from the ED without scheduling of a routine outpatient follow-up appointment.
DD: Direct Discharge

Due to severe pain, ED caregivers did not directly discharge four patients from the ED in the DD group. No other clinical indications for deviation from protocol were found in both study groups and these were attributed to unawareness of treatment protocols among ED staff.

Two patients physically reattended the ED after their initial visit in the DD group vs. 0 in the pre-DD group. One patient had a superficial wound infection, which was successfully treated with oral antibiotics for five days. The second patient could not bear weight on the injured foot after one week and was planned for additional outpatient follow-up. One patient in the DD group contacted the telephone helpline due to concerns about the recovery.

Forty-five (44%) out of 102 pre-DD patients and 50 (41%) out of 121 DD patients responded to the study questionnaire (Table 3).

Outcomes	Pre-DD (n = 102)	DD (n = 121)	p-value
Questionnaire response rate; n (%)	45 (44)	50 (41)	0.67
Satisfaction with treatment; median (range)	89 (45)	89 (53)	0.54
Persistent limitation of function; n (%)			1.0
None	45 (100)	50 (100)	
Rare: 1-2 times a week	0 (0)	0 (0)	
Regularly: 3-5 times a week	0 (0)	0 (0)	
On a daily basis: 6-7 times a week	0 (0)	0 (0)	
General practitioner visits; n (%)			0.37
0	37 (82)	43 (86)	
1	7 (16)	7 (14)	
2	0 (0)	0 (0)	
3	1 (2)	0 (0)	
Physiotherapist visits; n (%)			0.47
0	44 (99)	50 (100)	
1	0 (0)	0 (0)	
2	0 (0)	0 (0)	
>2	1 (1)	0 (0)	

Table 3: Patient-reported outcomes of respondents in the pre-DD and DD group.

DD: Direct Discharge

In both groups, similarly high satisfaction scores were reported by respondents. No persistent functional limitations were reported in both groups, indicating a full recovery of all patients. Regarding primary healthcare utilization, the number of visits to the general practitioner and physiotherapist was low and comparable between groups.

Both DTC costs and calculated outpatient clinic follow-up appointment costs were significantly reduced in DD patients compared to pre-DD patients (Table 4).

Outcomes	Pre-DD (n = 102)	DD (n = 121)	p-value
Secondary healthcare costs; median (range)			
Follow-up appointment costs*	$76 (228)	$ 0 (304)	<0.001
Follow-up radiographic imaging costs*	$ 0 (42)	$ 0 (42)	1.00
DTC costs**	$503 (795)	$ 302 (744)	<0.001

Table 4: Calculated secondary healthcare costs in pre-DD and DD patients.

*Based on a fixed price of $75,92 per follow-up appointment and $42,46 per radiograph.

DD: Direct Discharge; ED: Emergency Department; IQR: Interquartile range; DTC: Diagnosis Treatment Combination

**Data were missing in 3 (2%) DD patients

Costs for radiographic imaging at follow-up were similar between groups.

Discussion

This study shows that DD of children (aged ≤12) with a bicycle spoke injury reduced secondary healthcare utilization compared to traditional treatment, with a high protocol compliance rate. Use of DD did not result in an increase of ED reattendances. Additionally, respondents in both pre-DD and DD groups were highly satisfied with treatment, reported no persistent functional limitations were reported, and DD did not result in a shift of care towards the general practitioner or physiotherapist.

In our study, treatment with DD reduced the number of follow-up outpatient clinic appointments by approximately 80%. Other studies reporting on treatment of several injuries with similar DD protocols show comparable results for a variety of injuries [11,16,17]. This emphasizes the positive impact of DD on second-

ary healthcare resource utilization and available time of medical personnel. Additionally, a reduction of follow-up appointments contributes to more efficient time scheduling in outpatient clinics, leaving more time available for those patients who require this time and care. Our study shows this also applies to the treatment of the bicycle spoke injury specifically.

Furthermore, the high compliance rate of the DD protocol (88%) shows it the DD was well adopted in daily practice by ED caregivers. Furthermore, only 2% of directly discharged patients re-attended the hospital and no reported functional limitations were reported by questionnaire respondents, showing treatment of patients with a bicycle spoke injury, with minimal external wounds and no fracture, is safe. This is further underlined by the collected patient-reported outcomes, as satisfaction with treatment scores remained high following implementation of DD and no adverse functional outcomes were reported. Additionally, our study shows the burden of care does not shift from the hospital towards the primary healthcare setting, such as the general practitioner. Our findings are supported by previous studies showing similar positive results regarding on these outcomes following DD [9,11]. These positive results regarding safety of DD in children with bicycle spoke injuries may be attributed to strict DD inclusion criteria. Expansion of these criteria could potentially increase the number of patients eligible for treatment with DD, enhancing its effect on daily clinical practice. However, safety of expansion of DD criteria was outside the scope of this study and should be carefully monitored.

Regarding costs, both median calculated follow-up costs and median DTC costs were reduced following implementation of DD, which aligns with results from other studies showing a similar decrease in hospital treatment costs in terms of reduced secondary healthcare resource utilization [18,19]. Furthermore, a reduction of outpatient clinic follow-up appointments can lead to an additional reduction of social-economic costs. This is also reported in a study by Geerdink., *et al*., which showed a reduction of school-absenteeism for young patients and decreased work-absenteeism for accompanying parents and adults in a variety of injuries treated with DD [20]. However, these specific costs were outside the scope of this study.

Notably, this study has several limitations. First, limited data was available due to the retrospective study design. To counter this limitation, we used a study questionnaire to complement existing data. However, the questionnaire response rate in our study was moderate in both groups. Nevertheless, the combination of the low number of ED reattendances and follow-up appointments, absence of documented complications, and limited visits to general practitioners or physiotherapists indicate DD did not compromise safety of treatment in this study population. Another limitation was the subjective interpretation of wound characteristics by ED caregivers, which could have been influenced by interpersonal variability. However, positive results regarding reattendance rates show this interpretation was adequate in our study population. Finally, based on our data, only calculated median hospital treatment costs could be reported. We could not make definitive statements on the cost-effectivity of treatment with DD.

Future studies are needed to definitively determine physical function and patient satisfaction of patients with a bicycle spoke injury treated with DD. For this, adequate outcome measures should be considered carefully, as the use of current validated patient reported outcomes measures in children is debated due to limited evidence [21]. Furthermore, the increasing demand on trauma healthcare warrants careful consideration of resource utilization. This study showed an example in which routine follow-up at the outpatient clinic after an ED visit may be a form of overtreatment due to new alternative options. Future studies should focus on evaluating routine trauma care protocols for other injuries, to potentially optimize secondary healthcare utilization. This will aid caregivers in maintaining high-quality sustainable trauma care with less secondary healthcare resources.

Conclusion

In this study, treatment of children (aged ≤12) with a bicycle spoke injury through DD reduced secondary healthcare utilization compared to traditional treatment, with a high protocol compliance rate. Implementation of DD did not increase unplanned ED reattendances or negatively affect treatment outcomes.

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Conflict of Interest

The Authors declare that there is no conflict of interest.

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