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Incidence of Peroneal Nerve Injury due to Corrective Osteotomy: Systematic Review and Meta-Analysis

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Abstract
Introduction: Peroneal nerve injury is one of the complications of corrective osteotomy, a procedure to repair deformities of the bone and joint. We were determined to find incidence of peroneal nerve injury among patients underwent corrective osteotomy.
Methods: We conducted a systematic review and meta-analysis based on the PRISMA statement. Searching was carried out in several databases. Included studies after thorough screening were appraised using the JBI critical appraisal tools. Studies characteristics and results were extracted. Quantitative analysis was carried out to find the prevalence alongside the 95% confidence interval.
Results: We found 6 studies involving 788 subjects. We found that peroneal nerve injury occurred in 7.30% (95% CI = 1.34% – 17.47%) of corrective osteotomy cases. Two studies reported no injury done with mean angle repair of 9.9 ± 1.8 and 3.7 ± 1.2 degrees. There were variations of recommendations on osteotomy locations to reduce risk of peroneal nerve injury.
Conclusion: Peroneal nerve injury was observed in 7.30% of patients underwent corrective osteotomy. Better management and consideration in doing osteotomy could reduce the risk of peroneal nerve injury, hence increasing outcome and prognosis of the patients.

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Key Words
incidence, osteotomy, peroneal nerve, prevalence

Introduction

Peroneal nerve injury is a common injury which involves major nerves which contributed to the lower extremity. It could occur to both of superficial peroneal nerve and deep peroneal nerve, which innervate large area of various compartments of the leg. It has been accounted to various etiologies such as trauma, anatomic risk factors, external compressions, intraneural ganglion, peripheral nerve tumor, and iatrogenic injury.[1] It was commonly found in common peroneal nerve because of its location that lies along with the fibular neck.[1,2] Comorbidities such as diabetes mellitus, inflammation, motor neuron disease, and anorexia nervosa also increase risk of acquiring peroneal nerve injury.[2,3] It is usually recognized from incomplete ankle dorsiflexion and foot drop, alongside with paresthesia of lateral leg, forsal foot, and first toe webspace.[2] Patients with peroneal nerve injury usually show disability of foot eversion and/ot foot or toe dorsiflexion. Tinel sign could present in several cases which is accompanied by paresthesia or tingling. It was best observed with magnetic resonance imaging.[2,4]

Osteotomy is one of the risk factors contributing to occurrence of peroneal nerve injury.[4,5] Osteotomy or release of proximal tibiofibular joint is accounted to increased possibility to injure peroneal nerve.[6–8] A study reported that there was 4 out of 100 patients which were treated with lateral closing wedge high tibial osteotomy that developed peroneal nerve injury.[9,10] Another study reported that medial open-wedge high tibial osteotomy was accounted to increased risk of neurovascular injury, in which peroneal nerve injury was one of the most common complications.[5] Anatomical challenges have been recognized during osteotomy, which could increase risk of developing injury during drilling holes through osteotomy.[11] There have been several reports on peroneal nerve injury among corrective osteotomy patients.[5,11] However, the incidence of peroneal nerve injury among the population is yet to be known clearly. Therefore, we conducted a systematic review and meta-analysis to determine incidence of peroneal nerve injury in patients. Knowledge gained from this research was expected to help clinicians during decision-making of corrective osteotomy by giving consideration towards the incidence rate. Better decision-making was expected to improve patients' care, hence improving their overall outcome and prognosis.

Methods

We conducted a systematic review and meta-analysis based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement.[12] Searching was conducted on PubMed, EBSCOHost, EMBASE, WileyOnline, ProQuest, Scopus, and Google Scholar using searching strategies. We used keywords of "(Osteotomy) AND (("Peroneal Nerve"[Mesh]) AND (Injury))" for searching in PubMed and keywords of "((“Peroneal Nerve” OR “Fibular Nerve”) AND “Injury”) AND (“osteotomy”)" to conduct the searching in other databases. Inclusion and exclusion criteria were used to filter the studies. Inclusion criteria were as follows: (1) clinical trials; (2) studying patients underwent corrective osteotomy; (3) studying outcome of peroneal nerve injury; (4) adults' population. In addition, these exclusion criteria were applied: (1) written in other than English; (2) full article not available.

Studies passing the selection were appraised using the Joanna-Briggs Institute critical appraisal tools.[13] Studies' characteristics and results were extracted for qualitative and quantitative analysis. We determine primary outcome of peroneal nerve injury incidence among corrective osteotomy patients. Quantitative analysis was carried out using MedCalc version 18.0.[14] The heterogeneity of studies' results was assessed using Cochrane Q test and Higgins' I2 test.[15] Heterogeneity was determined if Q test results were less than 0.5 and/or result of I2 test more than 50%. Heterogeneously distributed data were assessed quantitatively using random-effect model, whereas homogenously distributed data were assessed quantitatively using fixed-effect model. Egger's test and Begg's test were carried to determine possibility of publication bias. Forest plot was used to present pooled analysis and funnel plot was used to assess risk of bias qualitatively. Proportion was used to present relationships between variables.

Results

We found six studies involving 766 subjects after thorough searching and selection whose process can be seen in Figure 1. Six studies consisted of five cohort studies and one case-control studies. Appraisal using the Joanna-Briggs Institute critical appraisal tools shown that all studies were in good condition, thus could be included in the analysis as could be seen in Table 1. Two studies were conducted in Asia and Europe, respectively, with one study each conducted in America and Africa. Studies were done between 1990 and 2017 with various mean age and proportion of gender, which could be observed in Table 2.[6,9,16–19]

Quantitative analysis of the studies showed that the studies' results were heterogeneously distributed ($I^2 = 92.01\%$, $p < 0.0001$). We found out that pooled incidence of peroneal nerve injury among corrective osteotomy patients were 7.30% (95% CI = 1.34% – 17.47%), which could be seen on Figure 2. Possibility of publication bias as result of heterogeneously distributed data was explored by funnel plot and analysis. Qualitative analysis using funnel plot did not show any indication of publication bias which could be seen on Figure 3. Analysis using Egger's test and Begg's test also confirmed that there was no indication of publication bias with p value of 0.14 and 0.57, respectively.

Discussion

Peroneal nerve injury was quite prevalent among populations underwent corrective osteotomy with incidence rate of 0.07. There are various mechanisms that lead to peroneal nerve injury according to the type of corrective osteotomy done. A report and cadaveric study by Itou et al reported that peroneal nerve injury among medial open-wedge high tibial osteotomy (MOWHTO) patients occurred due to location of deep peroneal neurovascular bundle which is about 10 mm to 15 mm from the tibia, which increases the risk of screw number 4 reaching the bundle while drilling was done.[20] Study by Jeong et al that studied patients underwent close-wedge high tibial osteotomy (HTO) reported that necessity of proximal tibiofibular release or fibular osteotomy increased risk of damaging peroneal nerve which is located nearby.[11] In case of fibular osteotomy, it was known that common personal nerve insertion which was located about 82 mm proximal towards the fibula increased risk of peroneal nerve injury due to osteotomy.[21] Study by Peskun explore risk factors of peroneal nerve injury and found that excessive body mass index, male gender, and fibular head fracture were the contributor of peroneal nerve injury after multivariate analysis with odds ratio of 1.14 (95% CI = 1.02 – 1.28), 5.47 (95% CI = 1.01 – 29.8), and 4.77 (95% CI = 1.40 – 16.20), respectively. The same analysis found that age, mechanism of injury, and posterior cruciate ligament injury were not significantly contributing to peroneal nerve injury after multivariate analysis was performed.[3]

There were two studies which have no peroneal nerve injury, in which the TFA angle correction could be considered as reference to minimize incidence of peroneal nerve injury in corrective osteotomy. Study by Ozcan et al reported that TFA angle correction was 9.9 ± 1.8 degrees, in which successfully converted varus condition (3.7 ± 1.2 degrees) into valgus condition (6.2 ± 1.6 degrees).[6] However, study by Duivenvoorden et al did not mention the amount of angle correction among patients.[9] A larger angle of correction was subjected to increased risk of developing peroneal nerve injury. Study by Aydogdu et al reported mean correction of 14.3 degrees which resulted in 27.27% rate of peroneal nerve injury.[18] Study by Slawski et al conducted corrective osteotomy with mean correction angle of between 18 degrees and 26 degrees, resulting in 4.31% rate of peroneal nerve injury.[17] Therefore, corrective osteotomy is recommended for patients with light to moderate valgus or varus deformation and not severe deformation as greater correction was related to greater risk of acquiring peroneal nerve injury. There were some cut-offs for severe deformity. A study by Karachlios et al define severe valgus or varus deformity as deformity of 20 degrees or more.[22] However, another study by Ranawat defined stricter cut-off with 10 degrees or more.[23] It is worthy to consider that the two studies which reported no peroneal nerve injury were the two most recent studies involved in the analysis, hence advancement in technology and methodology could be contributing factors towards better outcomes of the patients.

There are various measures to avoid peroneal nerve injury during corrective osteotomy. Among OWHTO patients, insertion of distal fixation screws is subjected to increased risk of injury towards neurovascular bundle. Therefore, the insertion should be conducted at more medial location.[20,24] In addition TriS plate is safer compared to TomoFix plate, hence plate selection should be considered carefully.[20] Fixation placement more anterior to the tibia alongside with small placement angle is another way to reduce injury towards interosseous membrane which could lead to peroneal nerve injury. In addition, it provides better stability.[25] This could be explained by improvement of popliteal artery injury risk by proximal screws if inserted anteriorly.[26] Study by Flierl et al tried to reduce risk of peroneal nerve injury on OWHTO patients by applying external fixator and conducting osteotomy in the middle shaft of fibular, which was successfully done in long term observation.[27] CWHTO was considered safer compared to OWHTO in terms of position of hardware insertion and proportion of soft tissue involved, which could be also considered in eligible corrective osteotomy patients to reduce the risk of peroneal nerve injury. Patients with OWHTO were subjected to more hardware removals compared to CWHTO, which can also increase the risk of peroneal nerve injury.[9,28–30] Study by Ogbemudia et al recommended that fibular osteotomy should be done in the lower halft of the fibula, to be more exact between the distal third and proximal two thirds of the fibula. This is the location which is quite distant from the neurovascular bundle but yields high stability, thus stability is not compromised.[19] Another studies described that peroneal nerve is located near the fibular head and neck, hence fibular osteotomy proximal one third of fibula is dangerous and needs to be avoided.[31,32]

There are several measures to be taken if peroneal nerve injury had taken place. Nonoperative management is the most popular option, including the use of ankle-foot orthoses and physical therapy. Surgery should be considered if there is no improvement after nonoperative therapy and/or patients develop severe case with rapidly deterioration of the peroneal nerve injury. In addition, open injuries with suspicion of nerve damage should be immediately administered for exploration and surgical repair by 72 hours the latest.[4]

This is among the first studies to pool prevalence of peroneal nerve injury among corrective osteotomy patients. Data gathered in this study was expected to help clinicians in formulation management for patients indicated for corrective osteotomy. However, this study was lacking data which make the data heterogenous. Therefore, we conducted more high-quality descriptive studies to be included in order to provide better conclusions. In addition, study exploring the risk factors of peroneal nerve injury in corrective osteotomy patients is recommended to be done to improve knowledge over this topic.

Conclusion

Peroneal nerve injury occurs in 7.30% of patients who completed corrective osteotomy. Better management and considerations among patients could reduce the incidence and improve their outcomes and prognosis.

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Attachment

Figure 1. Searching diagram of studies according to the PRISMA statement.[12]

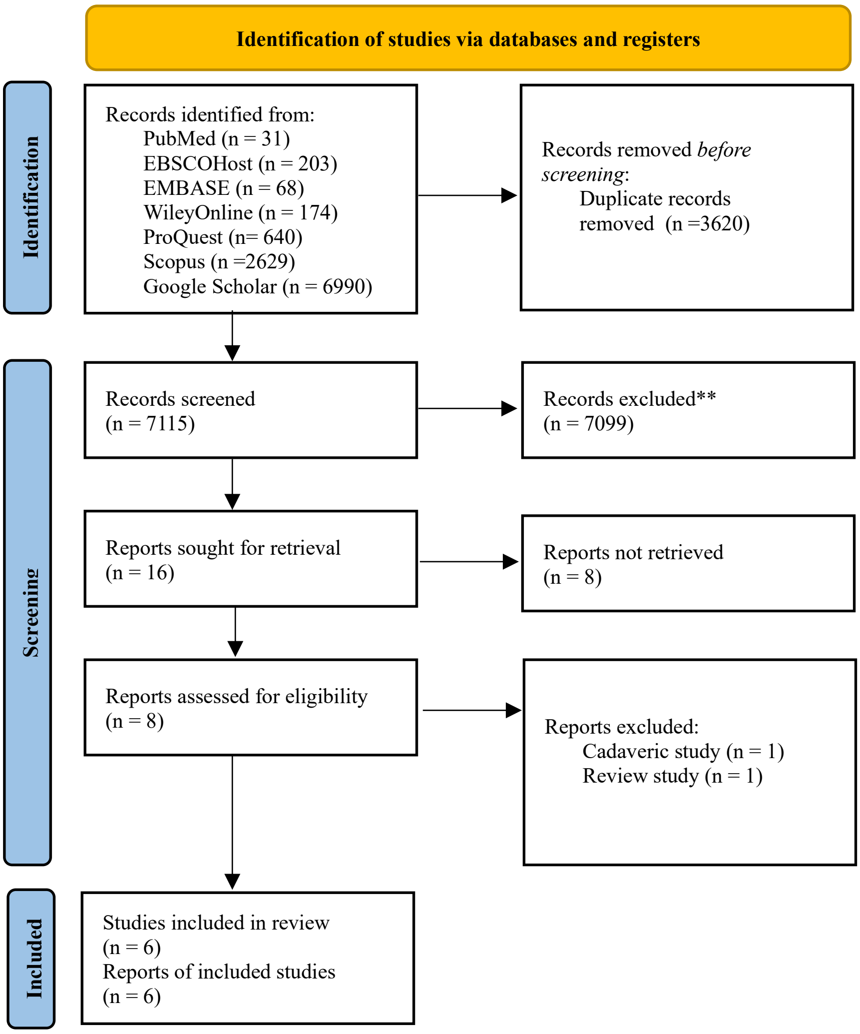

Figure 2. Forest plot of included studies.[6,9,16–19]

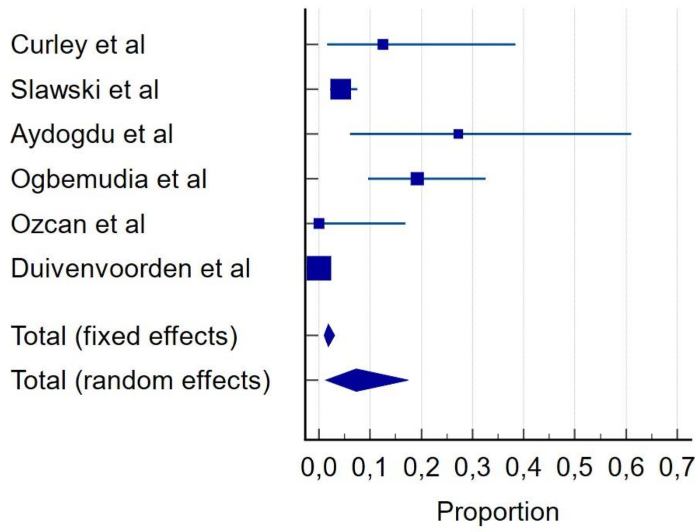

Figure 3. Funnel plot of included studies.[6,9,16–19]

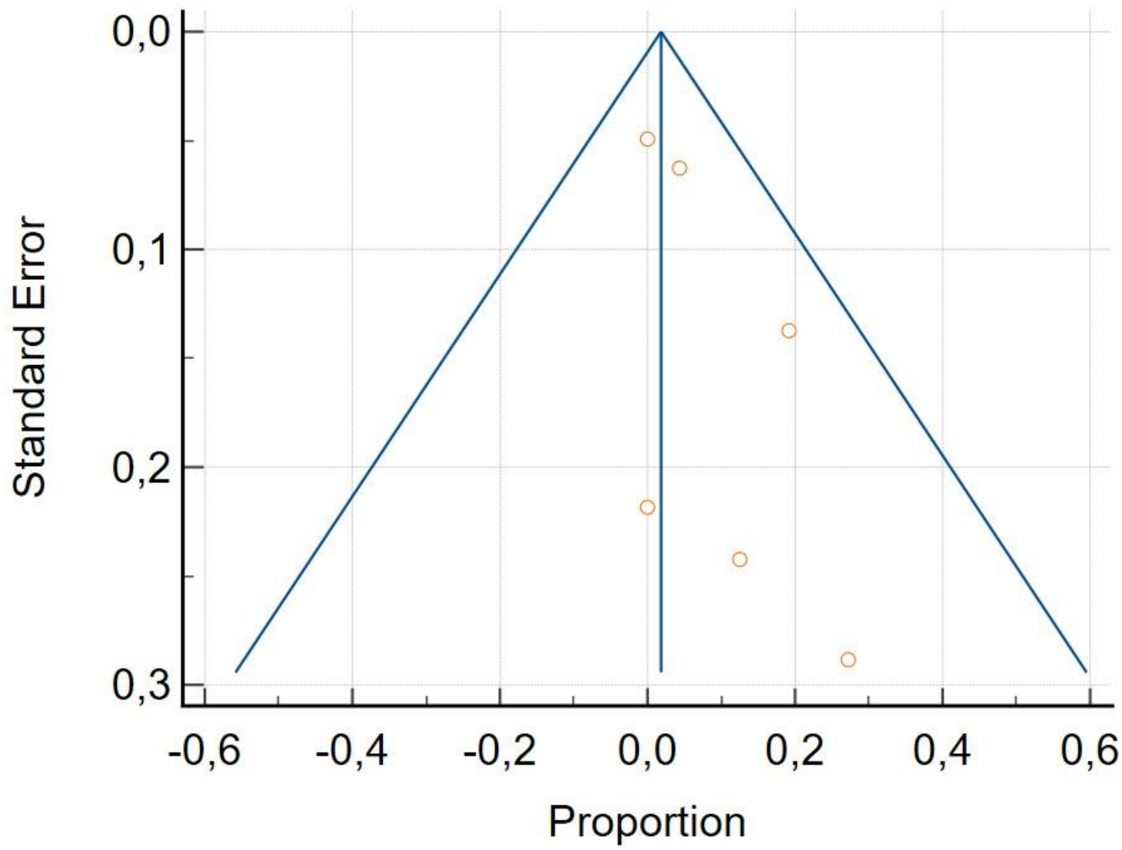

Figure 4. Meta Analysis: Proportion

Meta-analysis: proportion

Variable for studies	Authors
Variable for total number of cases	Subjects_n_ Subjects (n)
Variable for number of positive cases	PNI_n_ PNI (n)

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Curley et al	16	12,500	1,551 to 38,348	2,20	14,09
Slawski et al	255	4,314	2,173 to 7,587	33,16	20,11
Aydogdu et al	11	27,273	6,022 to 60,974	1,55	12,43
Ogbemudia et al	52	19,231	9,627 to 32,534	6,87	18,01
Ozcan et al	20	0,000	0,000 to 16,843	2,72	15,01
Duivenvoorden et al	412	0,000	0,000 to 0,891	53,50	20,34
Total (fixed effects)	766	1,841	1,015 to 3,058	100,00	100,00
Total (random effects)	766	7,299	1,337 to 17,472	100,00	100,00

Test for heterogeneity

Q	62,5958
DF	5
Significance level	P < 0,0001
I^2 (inconsistency)	92,01%
95% CI for I^2	85,37 to 95,64

Publication bias

Egger's test	
Intercept	3,8315
95% CI	-1,9061 to 9,5690
Significance level	P = 0,1373
Begg's test	
Kendall's Tau	0,2000
Significance level	P = 0,5730

Table 1. Critical appraisal of included studies using the Joanna-Briggs Institute tools for critical appraisal.[6,9,13,16–19]

Authors	Design	Appraisal Items											Conclusion
		1	2	3	4	5	6	7	8	9	10	11	
Curley et al	PC	NA	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y	Include
Slawski et al	RC	NA	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y	Include
Aydogdu et al	PC	NA	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y	Include
Ogbemudia et al	CC	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-	Include
Ozcan et al	PC	NA	Y	Y	Y	Y	Y	UC	Y	Y	NA	Y	Include
Duivenvoorden et al	RC	NA	Y	Y	Y	Y	Y	UC	Y	Y	Y	Y	Include

Abbreviations: PC = Prospective cohort; RC = Retrospective cohort; CC = Case-control; NA = Not applicable; Y = Yes; UC = Unclear

Table 2. Characteristics and results of included studies.[6,9,16–19]

Authors	Year	Location	Design	Type of CO	Duration (months)	Subjects (n)	Mean age (years)	Female (%)	PNI (n)
Curley et al	1990	United Kingdom	PC	HTO	12	16	64 (28-83)	25.0	2
Slawski et al	1994	United States	RC	TO	4.9 (1.0-11.0)	255	<18	54.1	11
Aydogdu et al	2000	Turkey	PC	HTO	6	11	58 (46-70)	81.8	3
Ogbemudia et al	2010	Nigeria	CC	Group I: VO of proximal tibia dan fibular Group II: VO of distal tibia and fibular	NA	52	10.4±2.2 11.4±2.3	50.0 56.0	10
Ozcan et al	2016	Turkey	PC	CW-HTO	27.5±14.3	20	50±4	95.0	0
Duivenvoorden et al	2017	Netherlands	RC	HTO	9.8±4.9	412	49.2±9.3	40.8	0

Abbreviations: PC = Prospective cohort; RC = Retrospective cohort; CC = Case-control; HTO = High tibial osteotomy; TO = Tibial osteotomy; VO = Valgus osteotomy; CW = Closed-wedge; NA = Not applicable; PNI = Peroneal nerve injury