



Original article

Shorter recovery can be achieved from using walking boot after operative treatment of an ankle fracture

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Abstract

Background/Objective: Ankle fractures, even if treated surgically, usually take a long time to heal. For all patients with ankle fracture, immobilisation is a critical part of treatment. Short-leg walking boots (WBs) have been reported to be an effective alternative to plaster casts (PCs) that could shorten this postoperative recuperative period. The aim of this study was to compare the functional recovery of a conventional PC with that of a WB after surgery for ankle fractures.

Methods: Forty-seven patients (mean age, 53.9 ± 12 years) who had undergone surgical operation for an unstable ankle fracture from January 2008 to October 2014 were reviewed retrospectively. Either a PC or a WB was prescribed postoperatively, with 25 patients and 22 patients, respectively. The time that it took the patient to stand unipedal on the affected side after allowing full-weight bear and to walk without crutches were used for assessment of functional recovery. The prevalence of postoperative loss of reduction and nonunion was also reviewed.

Results: Both the time of being able to stand unipedal on the injured side and to walk without crutches were significantly shorter in patients using WBs (WB, 2.6 weeks; PC, 4.5 weeks, $p = 0.01$; WB, 1.4 weeks; PC, 3.1 weeks, $p = 0.03$). There were no patients with loss of reduction or nonunion.

Conclusion: Patients who used WBs showed a significantly faster recovery. WBs have an adjustable heel lift that allows users to change the ankle position slightly plantarflexed that helps walking in a postoperative swollen ankle. WBs are easy to slip on, and it is easy to adjust the ankle position in conformity with swelling so that the least painful position could be maintained during walking. WBs have good fixity to allow immediate weight-bearing postoperatively, and there were no cases with loss of reduction postoperatively. The Rocker bottom design minimises the sagittal plane motion in the specific joint of the foot, which also facilitates the course of recuperation. An ankle fracture fixed appropriately endures loading when a WB is used. The WB treatment results in faster functional recovery, allowing the patients to return to normal activity at a faster rate.

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Keywords: ankle fracture; plaster cast; postoperative care; rehabilitation; walking boot

Introduction

Ankle fractures are relatively common,^{1–3} often occurring as a result of injuries during sports, a fall, or twisting the ankle. The treatment of an ankle fracture depends on the type of the fracture and patient factors. It may take time for a fracture to

heal even if it is treated surgically, The time required for the healing process can be affected by many factors, including the fracture type, age, underlying medical condition, and methods of rehabilitation. For all patients with ankle fracture, immobilisation is a critical part of treatment on rehabilitation regimens. Ankle fractures require restricting load on the affected ankle by putting on a plaster cast (PC) or a splint for a certain length of time. It has always been a challenge for orthopaedic surgeons to shorten this postoperative recuperative period. Numerous postoperative care regimens have been proposed

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including the method of immobilisation and when to start mobilisation and weight-bearing.^{4–18} Nevertheless, postoperative immobilisation of the ankle joint remains a critical component of postoperative care, although controversy persists regarding its method. Historically, Lindsjö¹⁹ applied a PC after an operation for ankle fracture. Since then, it has become the main immobiliser for the postoperative treatment of ankle fractures and injuries. Meanwhile, a semirigid functional orthosis is easy to use and has been shown to provide good functional results for stable lateral malleolar fractures.⁶ It suggested light immobilisation and promoted the idea that orthosis is good enough to maintain the stability only in the treatment for stable ankle fracture. A thorough consideration of the method of immobilisation depending on the condition of the postoperative ankle may be of benefit. Short-leg walking boots (WBs) have been reported to be an effective alternative to PCs for various foot and ankle diseases. Various advantages of removable WBs have been reported including the ease of application without requiring specialised training and the facility to take them off and perform range of motion (ROM) exercises.¹⁴ Yet, previous studies have only focused on the foot plantar pressure and gait patterns in WBs.^{20–22} Only a few reports have investigated their functional effects.⁴ In Japan, it is much less common to put on a WB than a PC after ankle surgeries. The aim of this study was to investigate the functional effect of WBs in patients with an ankle fracture treated surgically. The hypothesis was that the postoperative treatment of an ankle fracture with a WB would result in a better functional recovery compared to the conventional PC method. A retrospective, 6-month follow-up study of postoperative management of patients with ankle fracture was carried out, and functional evaluations were compared.

Materials and methods

The records of 47 patients (mean age, 53.9 ± 12 years) who were treated surgically for an ankle fracture at our hospital from January 2008 to October 2014 were reviewed retrospectively. This study was conducted in conformity with the principles of the Helsinki Declaration. The study was a retrospective review of the medical records and hence did not require a review by the Local Research Ethics Committee. The diagnosis was made with a plain radiograph, which was a displaced or an unstable fracture of the ankle including unimalleolar, bimalleolar, and trimalleolar injuries. Patients who were treated surgically and were followed up for at least 6 months were included. Patients with a pilon fracture of the tibia, an open fracture, multiple trauma, a history of previous ankle surgery, and who were unable to adhere to the postoperative protocol were excluded. The surgical procedure in all patients was an open reduction and an internal fixation in accordance with the AO/ASIF (Association for Osteosynthesis/Association for the study of Internal Fixation) methods.²³ Either a PC (25 patients) or a WB (22 patients) (Bledsoe Brace Systems, Grand Prairie, TX, USA: [Figure 1](#)) was prescribed postoperatively. The patient demographics are



Figure 1. Bledsoe Walking Boot used in the study.

given in [Table 1](#). Patients in the WB group were significantly older with more severe cases than those in the PC group.

Lateral malleolus fractures were fixed by using a plate and screws, and medial malleolus and posterior malleolus fractures were fixed by using screws. All patients were treated by general or spinal anesthesia.

After a rigid internal fixation, all patients were treated in a backslab half cast for 7–10 days postoperatively and were not allowed to weight-bear. After the stitches were removed, the PC group was managed with the conventional treatment of a below-knee PC. The primary surgeon decided when to start weight-bearing. The WB group was treated with WBs with weight-bearing as tolerated. All patients were seen weekly as outpatients by physiotherapists. Patients were advised to conduct exercises every day. Standard anteroposterior and lateral radiographs were taken at 14 days, 6 weeks, 3 months, and 6 months postoperatively to assess the healing of the fracture and the alignment of the affected ankle.

Functional recovery was assessed in terms of the time it took the patient to stand unipedal on the affected side after being allowed to full-weight bear, the time it took the patient to walk without crutches, and the final ROM of the affected ankle joint. The type of internal fixation (locking or non-locking), operative duration, and the time it took until the

Table 1
Basic characteristics and assessments in both groups.

	WB group (n = 22)	PC group (n = 25)	p
Basic characteristics			
Male/female	11/11	11/14	0.052
Age ^a (y)	53.9 ± 11.9	43.8 ± 16.1	0.026
Injury			
AO A1	2	2	
AO A2	0	2	
AO B1	6	8	
AO B2	5	5	
AO B3	8	2	
AO C1	0	3	
AO C2	1	2	
AO C3	1	0	
Dislocation fracture	10	3	
Assessments			
Nonlocking/locking	4/18	1/24	—
Surgical duration ^a (min)	118 ± 39.1	98 ± 36.1	0.108
Time the patients were allowed to put full weight on affected side ^a (wk)	5.5 ± 0.9	5.8 ± 1.5	0.732
Time that it took the patient to stand unipedal on the affected side after allowing full weight bearing ^a (wk)	1.4 ± 1.7	3.1 ± 2.2	0.003
Time that it took the patient to walk without crutches ^a (wk)	2.6 ± 1.8	4.5 ± 2.3	0.001
ROM of ankle ^a (difference between unaffected side)	5 ± 3.8	5.2 ± 2.8	0.842
Loss of reduction	0	0	—
Nonunion	0	0	—

PC = plaster cast; ROM = range of motion; WB = walking boot.

^a The scores are given as the mean ± standard deviation.

patients were allowed to put full weight on the affected ankle, as well as the prevalence of the postoperative loss of reduction and nonunion were also reviewed.

Statistical analysis

The data were analysed with SPSS statistical software (version 7; SPSS Inc., Chicago, IL, USA). After the descriptive analysis between the two groups, Mann–Whitney *U* test and Chi-square test were performed for continuous and categorical variables, respectively. In all tests, statistical significance was set at $p < 0.05$. The given significance levels refer to two-tailed tests. The results are expressed as the median ± interquartile range. Although we obtained a substantial amount of patient data, we chose a nonparametric test to obtain strict results and thus avoid type I error. Moreover, when we run both Kolmogorov–Smirnov test and Shapiro–Wilk tests, we could not confirm those parameters. Even though we ran parametric tests, there were no discrepancies from the nonparametric results.

Results

The WB group showed a significantly better functional recovery with significantly shorter times for the patient to stand unipedal on the affected side after allowing full-weight bear ($p = 0.01$) and to walk without crutches ($p = 0.03$). However, there was no significant difference in the final ROM between the two groups ($p = 0.842$). There were similar selections of the type of fixation, no significant difference in operative duration ($p = 0.108$) or the time that the patients

were allowed to put full weight on the affected ankle ($p = 0.732$). There were no patients with loss of reduction or nonunion (Table 1).

Discussion

The results of this study showed a superior functional recovery of the WB group regardless of the age differences and the severity of the injury. The times for the patients to stand unipedal on the affected side after allowing full-weight bear and to walk without crutches were significantly shorter after allowing full weight bearing. In this retrospective study, although the WB group had significantly more severe fractures and older patients, the group collectively showed a significantly faster recovery after full weight bearing was allowed. Multiple factors such as the choice of surgical implants, type of immobilisation and the rehabilitation regime are known to affect postoperative outcomes.^{5,6,8,11,12,14,24} In particular, the postoperative treatment protocols that have been reported in the literature vary and remain a subject of controversy.^{5,9,10,25,26} Several studies advocated early weight bearing on stable ankle fractures treated conservatively or after successfully performed osteosynthesis.^{5,15} However, it has not been easy to follow this concept in clinical practice as many patients complain about swelling and pain of the treated ankle. Previous studies showed that a WB reduces plantar pressure,^{22,27} but there is little consensus on what actually contributes to its reduction. It has been inferred that the fastening leg strap reduces the load on the ankle joint with a similar mechanism as a patella tendon bearing brace.^{28,29} The degree of the reduction in plantar pressure is affected by the size of the boot and the

circumference of the patient's lower limb, and hence the load to the ankle joint would not be constant.^{20–22,30,31} The load distribution would also differ according to the change in ankle position. Crenshaw et al²⁰ reported that placing the ankle in a 5° plantarflexed position would increase the pressure under the hindfoot, whereas the ankle in a dorsiflexed position would decrease it. WBs have an adjustable heel lift so that the ankle position could be modified to a slightly plantarflexed position, which facilitates walking in a postoperative swelling ankle. Although it is possible to apply the PC in a slightly plantarflexed position as well, it is difficult to determine the appropriate angle because the postoperative swelling condition varies depending on the time course. WBs are easy to slip on and make it easy for users to adjust the ankle position in conformity with swelling so that the patient can walk whilst the least painful position is maintained.

Another feature of the WB is the rocker bottom design (Figure 2). A rocker bottom shoe produces alteration in ankle biomechanics especially during the push-off phase in gait. It minimises the foot roll-over motion at the metatarsophalangeal joint of the foot.^{32–34} It is reasonable that the foot in a rocker bottom design would roll forward more to be flat with the ground rather than plantarflexing as it would naturally do in flat-bottom shoes. Also, the rocker bottom design facilitates roll-over motion. As a result, it has an effect on the reduction of the plantar pressure, especially at the forefoot.³² This rocker bottom design, combined with the ankle position, complicated the matter of weight-bearing. The muscle activity of the lower limb when using a rocker bottom design has been controversial—i.e. whether it is higher or similar compared to wearing standard shoes.^{32,35} Applying a below-knee cast for a long period leads to atrophy of the lower leg muscles.³⁶ As walking speed is known to be related to the strength of the distal lower leg muscles,^{37,38} prevention of their atrophy would be important to facilitate the course of early recuperation.

None of the patients showed loss of reduction or nonunion although the fracture site had been under loading after surgery. This finding indicates that an appropriately fixed ankle fracture could endure loading when the ankle is protected by a WB. Yet, when to start full weight bearing remains a matter of debate.⁵ The WB group started to weight-bear after 10–14 days after surgery. As a result, none of the participants had loss of reduction. However, all participants in this study had stable,

anatomically adequate fixations by surgery. Early weight bearing may be applied in patients who are considered to have had the fractures fixed firmly by operation. A previous systematic review showed that early weight-bearing tends to accelerate the return to work and daily activities compared to late weight-bearing.¹⁵ With regard to the risk of wound problems by an early weight-bearing regime,^{5,8} the reasonable time to start weight-bearing may be after the healing of the wound.

This study has several limitations. First, the investigation was retrospective and was conducted at a single general hospital with a relatively small number of patients. Second, the muscle volume of the lower limbs was not measured and hence, we were not able to measure muscle atrophy induced by immobilisation. A prospective randomised trial with sample size calculation that also includes the measurement of the muscle volume of the lower limbs in the two groups of WBs and PCs would be necessary to determine the benefit of a WB.

In conclusion, we compared the functional recovery of patients using a conventional PC with that of patients using a WB after undergoing surgery for ankle fractures. The WB group showed a significantly faster functional recovery. A WB has an adjustable heel lift allowing users to change the ankle position to a slightly plantarflexed position that facilitates walking in a postoperative swollen ankle. Furthermore, WBs are easy to slip on and make it easy to adjust the ankle position in conformity with the swelling so that the patient can walk whilst the least painful position is maintained. It is stable enough to allow immediate weight-bearing postoperatively, and no loss of reduction was seen. The Rocker bottom design minimises the sagittal plane motion in specific joints of the foot, which also facilitates the course of recuperation. An ankle fracture fixed appropriately endures loading when a WB is used. The WB treatment results in faster functional recovery, allowing the patients to return to normal activities at a faster rate.

Conflicts of interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

1. Bengner U, Johnell O, Redlund-Johnell I. Epidemiology of ankle fracture 1950 and 1980. Increasing incidence in elderly women. *Acta Orthop Scand.* 1986;57:35–37.



Figure 2. Rocker bottom sole of the walking boot.

2. Jensen SL, Andresen BK, Mencke S, Nielsen PT. Epidemiology of ankle fractures. A prospective population-based study of 212 cases in Aalborg, Denmark. *Acta Orthop Scand*. 1998;69:48–50.
3. Marvan J, Belehradkova H, Dzupa V, Baca V, Krbec M. [Epidemiological, morphological and clinical aspects of ankle fractures]. *Acta Chir Orthop Traumatol Cech*. 2012;79:269–274 [In Czech].
4. Biewener A, Rammelt S, Teistler FM, Grass R, Zwipp H. Functional postoperative treatment of internally fixed ankle fractures with a flexible arthrodesis boot (Variostabil). *Z Orthop Ihre Grenzgeb*. 2002;140:334–338.
5. Black JD, Bhavikatti M, Al-Hadithy N, Hakmi A, Kitson J. Early weight-bearing in operatively fixed ankle fractures: a systematic review. *Foot (Edinb)*. 2013;23:78–85.
6. Brink O, Staunstrup H, Sommer J. Stable lateral malleolar fractures treated with aircast ankle brace and DonJoy R.O.M.-Walker brace: a prospective randomized study. *Foot Ankle Int*. 1996;17:679–684.
7. Cimino W, Ichtertz D, Slabaugh P. Early mobilization of ankle fractures after open reduction and internal fixation. *Clin Orthop Relat Res*. 1991; 267:152–156.
8. Gul A, Batra S, Mehmood S, Gillham N. Immediate unprotected weight-bearing of operatively treated ankle fractures. *Acta Orthop Belg*. 2007;73: 360–365.
9. Harager K, Hviid K, Jensen CM, Schantz K. Successful immediate weight-bearing of internal fixated ankle fractures in a general population. *J Orthop Sci*. 2000;5:552–554.
10. Keene DJ, Williamson E, Bruce J, Willett K, Lamb SE. Early ankle movement versus immobilization in the postoperative management of ankle fracture in adults: a systematic review and meta-analysis. *J Orthop Sports Phys Ther*. 2014;44:690–701. C691–C697.
11. Lehtonen H, Jarvinen TL, Honkonen S, Nyman M, Vihtonen K, Jarvinen M. Use of a cast compared with a functional ankle brace after operative treatment of an ankle fracture. A prospective, randomized study. *J Bone Joint Surg Am*. 2003;85-A:205–211.
12. Lin CW, Moseley AM, Refshauge KM. Rehabilitation for ankle fractures in adults. *Cochrane Database Syst Rev*. 2008;CD005595.
13. Starkweather MP, Collman DR, Schuberth JM. Early protected weight-bearing after open reduction internal fixation of ankle fractures. *J Foot Ankle Surg*. 2012;51:575–578.
14. Polakoff DR, Pearce SM, Grogan DP, Burkhead WZ. The orthotic treatment of stable ankle fractures. *Orthopedics*. 1984;7:1712–1715.
15. Smeeing DP, Houwert RM, Briet JP, et al. Weight-bearing and mobilization in the postoperative care of ankle fractures: a systematic review and meta-analysis of randomized controlled trials and cohort studies. *PLoS One*. 2015;10:e0118320.
16. Stuart PR, Brumby C, Smith SR. Comparative study of functional bracing and plaster cast treatment of stable lateral malleolar fractures. *Injury*. 1989;20:323–326.
17. van Laarhoven CJ, Meeuwis JD, van der Werken C. Postoperative treatment of internally fixed ankle fractures: a prospective randomised study. *J Bone Joint Surg Br*. 1996;78:395–399.
18. Vioreanu M, Dudeney S, Hurson B, Kelly E, O'Rourke K, Quinlan W. Early mobilization in a removable cast compared with immobilization in a cast after operative treatment of ankle fractures: a prospective randomized study. *Foot Ankle Int*. 2007;28:13–19.
19. Lindsjo U. Operative treatment of ankle fractures. *Acta Orthop Scand Suppl*. 1981;189:1–131.
20. Crenshaw SJ, Pollo FE, Brodsky JW. The effect of ankle position on plantar pressure in a short leg walking boot. *Foot Ankle Int*. 2004;25:69–72.
21. Pollo FE, Gowling TL, Jackson RW. Walking boot design: a gait analysis study. *Orthopedics*. 1999;22:503–507.
22. Baumhauer JF, Wervey R, McWilliams J, Harris GF, Shereff MJ. A comparison study of plantar foot pressure in a standardized shoe, total contact cast, and prefabricated pneumatic walking brace. *Foot Ankle Int*. 1997;18:26–33.
23. ME AwM Müller, Schneider R, Willenegger H. *Manual of Internal Fixation. Technique Recommended by the AO-Group*. 2nd ed. New York: Springer; 1979.
24. Pires RE, Mauffrey C, de Andrade MA, et al. Minimally invasive percutaneous plate osteosynthesis for ankle fractures: a prospective observational cohort study. *Eur J Orthop Surg Traumatol*. 2014;24: 1297–1303.
25. Lin CW, Donkers NA, Refshauge KM, Beckenkamp PR, Khera K, Moseley AM. Rehabilitation for ankle fractures in adults. *Cochrane Database Syst Rev*. 2012;11:CD005595.
26. Van Laarhoven CJ, Oostvogel HJ, van der Werken C. [Differentiated protocol for the conservative/surgical treatment of ankle fractures in adults]. *Ned Tijdschr Geneesk*. 1996;140:2342–2349.
27. Pollo FE, Brodsky JW, Crenshaw SJ, Kirksey C. Plantar pressures in fiberglass total contact casts vs. a new diabetic walking boot. *Foot Ankle Int*. 2003;24:45–49.
28. Aita D, Bhav A, Herzenberg JE, Paley D, Cannada L. The load applied to the foot in a patellar ligament-bearing cast. *J Bone Joint Surg Am*. 1998; 80:1597–1602.
29. Alimerzaloo F, Kashani RV, Saeedi H, Farzi M, Fallahian N. Patellar tendon bearing brace: combined effect of heel clearance and ankle status on foot plantar pressure. *Prosthet Orthot Int*. 2014; 38:34–38.
30. Brown D, Wertsch JJ, Harris GF, Klein J, Janisse D. Effect of rocker soles on plantar pressures. *Arch Phys Med Rehabil*. 2004;85:81–86.
31. Johanson MA, Cooksey A, Hillier C, Kobbeman H, Stambaugh A. Heel lifts and the stance phase of gait in subjects with limited ankle dorsiflexion. *J Athl Train*. 2006;41:159–165.
32. Hutchins S, Bowker P, Geary N, Richards J. The biomechanics and clinical efficacy of footwear adapted with rocker profiles—evidence in the literature. *Foot (Edinb)*. 2009;19:165–170.
33. Myers KA, Long JT, Klein JP, Wertsch JJ, Janisse D, Harris GF. Biomechanical implications of the negative heel rocker sole shoe: gait kinematics and kinetics. *Gait Posture*. 2006;24:323–330.
34. Wu WL, Rosenbaum D, Su FC. The effects of rocker sole and SACH heel on kinematics in gait. *Med Eng Phys*. 2004;26:639–646.
35. Sacco IC, Sartor CD, Cacciari LP, et al. Effect of a rocker non-heeled shoe on EMG and ground reaction forces during gait without previous training. *Gait Posture*. 2012;36:312–315.
36. Psatha M, Wu Z, Gammie FM, et al. A longitudinal MRI study of muscle atrophy during lower leg immobilization following ankle fracture. *J Magn Reson Imaging*. 2012;35:686–695.
37. Bassey EJ, Bendall MJ, Pearson M. Muscle strength in the triceps surae and objectively measured customary walking activity in men and women over 65 years of age. *Clin Sci (Lond)*. 1988;74:85–89.
38. Bendall MJ, Bassey EJ, Pearson MB. Factors affecting walking speed of elderly people. *Age Ageing*. 1989;18:327–332.