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# Operative treatment of geriatric ankle fractures with conventional or locking plates. A retrospective case-control study

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ABSTRACT

*Background:* The incidence of geriatric ankle fractures continues to rise due to demographic changes. While locking plates have become standard implants for injuries of other body regions, clinical studies on their use for geriatric ankle fractures are rare.
*Methods:* Therefore, a retrospective case-control study, including 333 patients with a mean age of 73.5 years was performed. 263 patients underwent operative fixation with one- third tubular plates and 70 were treated with locking plates. Early outcomes and complication rates of locking plates as compared with conventional one- third tubular plates are described.
*Results:* In the present study, patients treated with locking plates were older and suffered from more severe fracture patterns. In addition, these patients had more severe comorbidities. Treatment with conventional or locking plate fixation resulted in a comparable complication and revision rate. A matched pair analysis showed significantly more complications and required revision surgeries and a trend towards more implant failures in the group that underwent conventional plating.
*Conclusions:* Therefore, we conclude that precontoured locking plates represent an appropriate treatment option for severe ankle fractures in patients suffering from relevant co-morbidities. Prospective randomized trials are warranted to prove superiority of locking plates for treatment of geriatric ankle fractures.
Level 3: Retrospective case- control study.
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## 1. Introduction

Ankle fractures are common skeletal injuries with an incidence of 122 fractures per 100,000 persons [1]. Due to demographic changes the incidence in the geriatric population continued to rise. A 163% increase in the incidence of low-trauma ankle fractures in elderly people over a 30 year study period was described [2].

Although the question if geriatric fractures should be treated operatively or nonoperatively remains controversial, higher functional demands of geriatric patients result in a trend to more operative interventions [3]. Furthermore, the prevalence of co-morbidities is increased in older patients with ankle fractures resulting in high complication rates [4–6]. Co-morbidities, especially diabetes and peripheral vascular disease were identified to be associated with an increased risk for developing perioperative complications after operative fixation of geriatric ankle fractures [4,5,7–9]. Implant failure in osteoporotic bone represents the second most frequent complication in the geriatric population following impaired wound healing [4,5,10].

For fragility fractures in other body regions (e.g. the distal radius or the proximal humerus) precontoured locking plates have become the standard treatment due to advantages in initial stable fixation [11]. Although several biomechanical studies proved increased stability of locking plates in osteoporotic ankle fractures [12–14], clinical studies are rare.

Therefore the aim of the present retrospective case- control study was to describe early outcome and complication rates of locking plates as compared with conventional one- third tubular plates.

## 2. Patients and methods

All patients who underwent operative treatment of an ankle fracture between January 2004 and December 2016 in our

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institution were retrospectively analysed. Patients under the age of 65 years as well as patients with incomplete medical chart records and those not initially treated in our institution were excluded. Designed as a retrospective study, a formal approval of the local ethical committee was not required.

In patients with persistent dislocation despite closed reduction and cast immobilisation, temporary external fixation was performed. For definitive surgical fixation, all patients were treated with conventional one- third tubular plates (see Fig. 1a and b) between 2004 and 2011. Since 2011, locking plates (VariAx Distal Lateral Fibula Locking Plate, Stryker, Schönkirchen, Germany) were available and used in our institution (see Fig. 1c). The choice of implant was left at the responsible surgeon's discretion. In case of syndesmotic rupture, a rigid fixation with a tetracortical 3.5 mm tibiofibular screw was performed (see Fig. 1a). Fixation of fractures of the medial malleolus was either performed using screws or with a tension-band wiring technique. Routine medial or lateral ligament reconstruction was not performed.

Routinely, isolated fractures classified as type A according to Weber were treated nonoperatively. In stable fractures with non or minimally dislocation pros and cons of operative and nonoperative treatment were explained and the decision was left at the patient's discretion. Demographic and patient factors, such as age, gender, trauma mechanism, fracture type according to the Weber classification [15], presence of an open fracture, co-morbidities (using the Charlson Score) [16], and the American Society of


**Fig. 1.** (a) Postoperative X ray after surgical fixation with a one third tubular plate (antero-posterior view). (b) Implant failure with loosening of the distal screws 4 month after surgical fixation; (antero-posterior view). (c) Re-osteosynthesis with a locking plate (antero-posterior view).

Anaestesiologists (ASA) score [17] were recorded. Further clinical data e.g. operation time, in-patient time, required treatment on the operative intensive care unit (SICU) were recorded. Complications including surgery related complications and hospital acquired infections as well as the necessity of a revision surgery was assessed. Patients were divided in two subgroups: *one-third tubular plates* and *locking plates*. Groups were compared regarding demographic data, treatment, complication rates, type of complication and revision rates. In addition, a matched pair analysis was performed using the best fit approach considering age, the Charlson Comorbidity Index, number of affected malleoli, Weber classification and performed temporary operative fixation.

Data was collected and a pseudonymization was performed using an Excel 2007 database (Microsoft Corporation, Redmond, WA, USA). For statistical analysis, SPSS (IBM SPSS Statistics 22, Statistical Package for the Social Science, IBM Cooperation, Armonk, N.Y., USA) was used for the explorative data analysis. Descriptive statistics were used to describe the clinical characteristics as well as functional and radiological outcomes. Data is presented as mean and range. Bivariate comparisons were made using the Chi-square test for dichotomic data. Means were compared using Mann–Whitney–Wilcoxon test. A p value of $<0.05$ was considered to be significant.

## 3. Results

In total, 333 patients met the inclusion criteria. 263 (79%) were treated with conventional one-third tubular plates and 70 (21%) were treated with precontoured locking plates. During the study period, 52 patients were treated without operative fixation, including 48 type B and 4 type C fractures.

### 3.1. Demographic and patient factors

Analysis of gender distribution between both groups revealed more females in the locking plate group ($p = 0.001$). Patients treated with locking plates were significantly older compared to those who underwent operative fixation with conventional plates ($p < 0.001$). There was no difference regarding the trauma mechanism of the index injury with distorsions and simple falls representing the most common mechanisms.

Comparison of co-morbidities showed that patients treated with locking plates had a significantly higher Charlson Comorbidity Index ($p = 0.029$) and ASA score ($p < 0.001$). There was no significant difference in the prevalence of diabetes and peripheral vascular disease, while patients who underwent locking plate fixation significantly more often suffered from osteoporosis ($p = 0.001$).

Analysis of the number of fractured malleoli showed that in patients treated with locking plates more malleoli were affected ($p = 0.019$). No difference was detected regarding the Weber classification ($p = 0.1$).

A temporary external fixation due to persistent dislocation after closed reduction and cast fixation was more frequently required in patients treated with locking plates ($p = 0.002$) (see Table 1).

**Table 1**
Patient and fracture characteristics for both patient groups.

| | Locking plates | Conventional plates | p- Value |
|---|---|---|---|
| N= | 70 | 263 | |
| Gender (m/w) | 9/61 | 87/176 | **0.001** |
| Age | 76.59 (65–98) | 72.61 (65–92) | **<0.001** |
| Trauma mechanism | | | 0.319 |
| - Distorsion | 38 (54.29%) | 146 (55.51%) | |
| - Fall | 28 (40%) | 106 (40.3%) | |
| - Motor vehicle accident | 4 (5.71%) | 6 (2.28%) | |
| - Direct low energy impact | 0 | 5 (1.9%) | |
| ASA score | 2.76 (1–4) | 2.42 (1–4) | **<0.001** |
| Charlson Comorbidity Index | 1.40 (0–8) | 0.89 (0–7) | **0.029** |
| Diabetes (yes/no) | 13/57 | 53/210 | 0.768 |
| Peripheral vascular disease (yes/no) | 5/65 | 8/255 | 0.115 |
| Osteoporisis (yes/no) | 16/54 | 22/241 | **0.001** |
| Fracture type (Weber- classification) | | | 0.1 |
| - Weber A | 0 | 3 (1.14%) | |
| - Weber B | 41 (58.57%) | 184 (69.96%) | |
| - Weber C | 29 (41.43%) | 76 (28.9%) | |
| Number of fractured malleoli | | | **0.019** |
| - Distal fibula | 24 (34.29%) | 137 (52.09%) | |
| - Bimalleolar | 17 (24.29%) | 56 (21.29%) | |
| - Trimalleolar | 29 (41.43%) | 70 (26.62%) | |
| Open fracture (yes/no) | 4/66 | 13/250 | 0.794 |
| Concomitant fractures (yes/no) | 6/64 | 21/242 | 0.873 |
| Temporary operative fixation necessary? (yes/no) | 31/39 | 66/197 | **0.002** |

A p value of $<0.05$ was considered to be significant. All bold values are p values $< 0.05$.

### 3.2. Clinical data and complications

The in-patient time and the interval between trauma and surgery were similar in both groups. Operation time was significantly increased in the locking plate group ($p = 0.012$). Ten patients in the locking plate group (14.29%) were postoperatively observed on the ICU compared to 21 patients in the conventional plate group (9.51%) ($p = 0.247$).

The overall complication rate did not significantly differ between both groups ($p = 0.699$). The three most common complications (wound complications including wound dehiscence as well as superficial and deep wound infection; implant failure (see Fig. 1b); hospital acquired complications) were compared between both groups and no significant differences were found. Rare complications in this study were two cases of hematoma requiring revision surgery (one patient in each group), three cardial complications (one in the locking plate and two in the conventional group) and two cases of intraarticular fragments, which were arthroscopically removed (both in the conventional plate group). The incidence of required revision surgery (see Fig. 1c) did not significantly differ between both groups ($p = 0.181$) (see Table 2).

The performed matched pair analysis excluded significant differences between both groups. Significantly more complications ($p = 0.004$) and required revision surgeries ($p = 0.003$) in fractures stabilized with conventional plate osteosynthesis were detected. Furthermore, a trend towards an increased incidence of implant failures ($p = 0.063$) was seen as compared to the locking plate group. No differences were found regarding wound complications and hospital acquired infections (see Table 3).

## 4. Discussion

The present retrospective case control study revealed high complication rates after operative fixation of geriatric ankle fractures. In the whole study population, no significant differences after stabilization with conventional or locking plates regarding complications or required operative revisions were present. In

**Table 2**
Early outcome and complications.

| | Locking plates | Conventional plates | p- Value |
|---|---|---|---|
| N= | 70 | 263 | |
| Hospital stay (days) | 15.74 (4–61) | 13.96 (2–70) | 0.346 |
| Trauma- surgery (days) | 6.91 (2–16) | 6.41 (0–35) | 0.262 |
| Operation time (minutes) | 75.71 (28–193) | 65.36 (15–227) | **0.012** |
| ICU treatment (yes/no) | 10/60 | 25/238 | 0.247 |
| Complication (yes/no) | 16/54 | 66/197 | 0.699 |
| Implant failure (yes/no) | 1/69 | 8/255 | 0.691 |
| Wound- complication (yes/no) | 10/60 | 47/216 | 0.479 |
| Hospital acquired complications (yes/no) | 4/66 | 11/252 | 0.529 |
| Revision surgery (yes/no) | 5/65 | 34/229 | 0.181 |

A p value of <0.05 was considered to be significant. All bold values are p values < 0.05.

patients with locking plate osteosynthesis, a more severe fracture pattern was seen and more severe comorbidities were present. To improve the interpretability, an additional matched pair analysis was performed showing significant more complications and required revision surgeries as well as a trend towards more implant failures in the group with conventional plate osteosynthesis.

The incidence of geriatric ankle fractures continues to rise due to demographic changes and increased activity levels in elderly patients [1,2]. Increased functional demands of older patients resulted in a trend from nonoperative treatment to operative interventions. In a recent study including nearly 20,000 patients with an age >65 years, operative treatment was performed in 77% [3]. However, optimal treatment for geriatric ankle fractures remains controversial [18]. Non-operative treatment has been associated with high rates of non- or mal-union [19,20]. Otherwise, previous studies have reported high complication rates after operative fixation of geriatric ankle fractures [5,6,10,21,22]. Confirming previous reports [4,5,10,23], impaired wound healing represented the most common complication in the present study.

To reduce the risk for peri-operative complications following operative fixation of ankle fractures new stabilization techniques with locking plates or primary arthrodesis with a calcaneotalotibial nail have been described in the recent literature [24,25]. Treatment of unstable ankle fractures with a calcaneotalotibial nail in frail elderly patients resulted in 4% surgical site infections, 2% deep infections and 6% broken or loose locking screws within six month after the operation [24]. Although the authors concluded that the calcaneotalotibial nail is an excellent device for treating an unstable geriatric ankle fractures with immediate mobilization, impaired wound healing obviously remains a major problem. Comparison to the present study is limited by the fact that the procedure was only considered for frail patients with low functional demands.

Poor bone quality in geriatric patients causes difficulties in achieving anatomical reduction and maintaining a stable fixation [5] resulting in an increased risk for implant failure. Locking plates follow the internal fixator concept compared to the buttress/neutralization concept of conventional plates. This offers the advantage of stronger screw fixation in osteoporotic bone. On the other hand the disadvantage of a more rigid implant does not always fit to the individual anatomy of distal fibula potentially resulting in malunion of the fibula. To achieve stable fixation in osteoporotic bone, locking plates represent the standard implant in other fragility fractures such as distal radius or humeral fractures [11]. Previous biomechanical studies showed that locking plates provide improved initial stability for ankle fractures in osteoporotic bone [12,13]. In contrast, no advantages of locking plates were detected in specimens with normal bone mineral density [26].

Clinical studies comparing conventional and locking plate fixation of ankle fractures are rare. Huang et al. compared the results of a conventional one-third tubular plate with two different locking plates in patients representing all age groups. Healing time as well as functional scores after 12 months were improved in patients treated with locking plates while no influence on complication rates was detected [25]. In another retrospective analysis of closed distal fibular fractures, an increased incidence of wound complications was detected after treatment with locking plates as compared to fixation with non-locking plates [27]. No distinct criteria for locking plates were provided in this study. Thus, it may be possible that locking plates were used in patients with more severe soft tissue damage or worse bone quality explaining an increased complication rate although both groups did not differ regarding patient and fracture characteristics. In addition, the thicker design of locking plates could potentially lead to a higher incidence of wound complications. Tsukuda et al. performed a prospective randomized controlled trial comparing the results of locking versus non-locking plates for ankle fractures with a 12 month follow up period. No significant differences regarding the osseous union rate, the SF 36 Score and the complication rate were present [28]. However, these three studies did include patients of all ages while in the current analysis only geriatric patients with an assumed reduced bone quality were assessed.

**Table 3**
Data of the matched pair analysis.

| | Locking plates | Conventional plates | p-Value |
|---|---|---|---|
| N= | 70 | 70 | |
| Gender (m/w) | 9/61 | 12/58 | 0.478 |
| Age | 76.59 (65–98) | 76.04 (65–92) | 0.772 |
| Charlson Comorbidity Index | 1.40 (0–8) | 1.36 (0–5) | 0.527 |
| Fracture type (Weber- classification) | | | 0.730 |
| - Weber B | 41 (58.575%) | 43 (61.43%) | |
| - Weber C | 29 (41.43%) | 27 (38.57%) | |
| Number of fractured malleoli | | | 0.853 |
| - Distal fibula | 24 (34.29%) | 27 (38.57%) | |
| - Bimalleolar | 17 (24.29%) | 15 (21.43%) | |
| - Trimalleolar | 29 (41.43%) | 28 (40%) | |
| Temporary operative fixation necessary? (yes/No) | 31/39 | 28/42 | 0.608 |
| Open fracture (yes/no) | 4/66 | 5/65 | 1.0 |
| Complication (yes/no) | 16/54 | 32/38 | **0.004** |
| Implant failure (yes/no) | 1/69 | 7/63 | 0.063 |
| Wound- complication (yes/no) | 10/60 | 18/52 | 0.091 |
| Hospital acquired complications (yes/no) | 4/66 | 9/61 | 0.243 |
| Revision surgery (yes/no) | 5/65 | 18/52 | **0.003** |

A p value of <0.05 was considered to be significant. All bold values are p values < 0.05.

In the present study, patients treated with locking plates were older and suffered from more severe comorbidities as measured with the Charlson Comorbidity Index. In addition, these patients presented with more severe fracture patterns as compared to patients with conventional plate osteosynthesis. One would expect that these factors may have led to more severe soft tissue impairment and consecutive increased complication rates. The fact that both groups had comparable complication and revision surgery rates may indicate to advantages of locking plates under these conditions. This statement is supported by the matched pair analysis showing an increased incidence of complications and required revision surgeries in the conventional plating group.

### *4.1. Strengths and limitations*

The results of the present study are limited by several factors. The most important limitation is the retrospective study design. Specifically, the retrospective design prevented evaluation of the indication for usage of locking plates since the choice of the implant was left at the responsible surgeon's discretion. Although patients' records were carefully reviewed, data is strongly dependent on the quality of documentation. In addition we could not comment on bone quality since bone mineral density is not routinely measured in our institution. Another limitation is the large difference in group size and demographic parameters between the two groups, which makes comparisons difficult. The strength of the present study is the high number of included patients with geriatric ankle fractures with detailed information of pre-existing comorbidities.

## 5. Conclusion

Although, conventional plates represent the golden standard of treatment in ankle fractures precontoured locking plates represent an appropriate treatment option for severe ankle fractures in patients suffering from relevant co-morbidities. Prospective randomized trials are warranted to prove superiority of locking plates for treatment of geriatric ankle fractures.

## Authors' contributions

All authors made substantial contributions to the conception and design of the study. Research design: RA, SR, MF. Acquisition of data: RA. Interpretation of data: RA, PL, CKB, MF. Drafting of the manuscript: RA, SR, MF. Revision of the manuscript: PL, CKB, MF. All authors have read and approved the final manuscript.

## Conflict of interest

The authors declare that they have no conflict of interest.

## References

[1] Court-Brown C.M., McBirnie J, Wilson G. Adult ankle fractures-an increasing problem? Acta Orthop Scand 1998;69:43–7.
[2] Kannus P, Palvanen M, Niemi S, Parkkari J, Järvinen M. Increasing number and incidence of low-trauma ankle fractures in elderly people: Finnish statistics during 1970–2000 and projections for the future. Bone 2002;31:430–3.
[3] Bariteau JT, Hsu RY, Mor V, Lee Y, DiGiovanni CW, Hayda R. Operative versus nonoperative treatment of geriatric ankle fractures: a Medicare Part A claims database analysis. Foot Ankle Int 2015;36:648–55.
[4] Lynde MJ, Sautter T, Hamilton GA, Schuberth JM. Complications after open reduction and internal fixation of ankle fractures in the elderly. Foot Ankle Surg 2012;18:103–7.
[5] Zaghloul A, Haddad B, Barksfield R, Davis B. Early complications of surgery in operative treatment of ankle fractures in those over 60: a review of 186 cases. Injury 2014;45:780–3.
[6] Carragee EJ, Csongradi JJ, Bleck EE. Early complications in the operative treatment of ankle fractures: Influence of delay before operation. J Bone Joint Surg Br 1991;73:79–82.
[7] Costigan W, Thordarson DB, Debnath UK. Operative management of ankle fractures in patients with diabetes mellitus. Foot Ankle Int 2007;28:32–7.
[8] Regan DK, Manoli A, Hutzler L, Konda SR, Egol KA. Impact of diabetes mellitus on surgical quality measures after ankle fracture surgery: implications for "value-based" compensation and "pay for performance". J Orthop Trauma 2015;29:e483–6.
[9] Belmont PJ, Davey S, Rensing N, Bader JO, Waterman BR, Orr JD. Patient-based and surgical risk factors for 30-day postoperative complications and mortality after ankle fracture fixation. J Orthop Trauma 2015;29:e476–82.
[10] Aigner R, Salomia C, Lechler P, Pahl R, Frink M. Relationship of prolonged operative time and comorbidities with complications after geriatric ankle fractures. Foot Ankle Int 2017;38:41–8.
[11] Anglen J, Kyle RF, Marsh JL, Virkus WW, Watters WC, Keith MW, et al. Locking plates for extremity fractures. J Am Acad Orthop Surg 2009;17:465–72.
[12] Kim T, Ayturk UM, Haskell A, Miclau T, Puttlitz CM. Fixation of osteoporotic distal fibula fractures: a biomechanical comparison of locking versus conventional plates. J Foot Ankle Surg 2007;46:2–6.
[13] Zahn RK, Frey S, Jakubietz RG, Jakubietz MG, Doht S, Schneider P, et al. A contoured locking plate for distal fibular fractures in osteoporotic bone: a biomechanical cadaver study. Injury 2012;43:718–25.
[14] Eckel TT, Glisson RR, Anand P, Parekh SG. Biomechanical comparison of 4 different lateral plate constructs for distal fibula fractures. Foot Ankle Int 2013;34:1588–95.
[15] BGW. Die Verletzungen des oberen Sprunggelenkes. Berne: Verlag Hans Huber; 1972.
[16] Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–83.
[17] Anaestesiologists ASo. American Society of Anesthesiologists. ASA physical status classification system. http://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system2015.
[18] Donken CC, Al-Khateeb H, Verhofstad MH, van Laarhoven CJ. Surgical versus conservative interventions for treating ankle fractures in adults. Cochrane Database Syst Rev 2012;8: CD008470.
[19] Ali MS, McLaren CA, Rouholamin E, O'Connor BT. Ankle fractures in the elderly: nonoperative or operative treatment. J Orthop Trauma 1987;1:275–80.
[20] Anand N, Klenerman L. Ankle fractures in the elderly: MUA versus ORIF. Injury 1993;24:116–20.
[21] Beauchamp CG, Clay NR, Thexton PW. Displaced ankle fractures in patients over 50 years of age. J Bone Joint Surg Br 1983;65:329–32.
[22] Anderson SA, Li X, Franklin P, Wixted JJ. Ankle fractures in the elderly: initial and long-term outcomes. Foot Ankle Int 2008;29:1184–8.
[23] Srinivasan CM, Moran CG. Internal fixation of ankle fractures in the very elderly. Injury 2001;32:559–63.
[24] Al-Nammari SS, Dawson-Bowling S, Amin A, Nielsen D. Fragility fractures of the ankle in the frail elderly patient: treatment with a long calcaneotalotibial nail. Bone Joint J 2014;96-B:817–22.
[25] Huang Z, Liu L, Tu C, Zhang H, Fang Y, Yang T, et al. Comparison of three plate system for lateral malleolar fixation. BMC Musculoskelet Disord 2014;15:360.
[26] Nguyentat A, Camisa W, Patel S, Lagaay P. A biomechanical comparison of locking versus conventional plate fixation for distal fibula fractures in trimalleolar ankle injuries. J Foot Ankle Surg 2016;55:132–5.
[27] Schepers T, Van Lieshout EM, De Vries MR, Van der Elst M. Increased rates of wound complications with locking plates in distal fibular fractures. Injury 2011;42:1125–9.
[28] Tsukada S, Otsuji M, Shiozaki A, Yamamoto A, Komatsu S, Yoshimura H, et al. Locking versus non-locking neutralization plates for treatment of lateral malleolar fractures: a randomized controlled trial. Int Orthop 2013;37:2451–6.