K-wire transfixation or distraction following the Keller-Brandes arthroplasty in Hallux rigidus and Hallux valgus?

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Abstract A total of 118 feet with Hallux valgus and Hallux rigidus treated by the Keller-Brandes method were re-examined clinically and radiologically after 9.1 years (range: 1.7–24.3). Correction of the Hallux valgus angle was obtained from an average of 40° to 23° in the Hallux valgus group. Improvement in the postoperative range of motion was observed when the aftertreatment consisted of Kirschner-wire distraction instead of an axial Kirschner-wire transfixation. The patients who underwent Keller-Brandes surgery for Hallux valgus had less pain when the aftertreatment was carried out using an axial Kirschner wire, while those operated on for Hallux rigidus had less pain when the aftertreatment consisted of distraction. The percentage of satisfied or very satisfied patients with the cosmetic results of the Keller-Brandes arthroplasty was more than 66.7%. Patients with Hallux valgus and postoperative aftertreatment with Kirschner wire transfixation were the most satisfied patients, while patients with Hallux rigidus were very satisfied with the postoperative distraction. Our good results are comparable to those in other studies and confirm the success of the Keller-Brandes resection arthroplasty in Hallux valgus with osteoarthritis of the first metatarsophalangeal joint in older patients whose demand for movement is less, and in Hallux rigidus in less active older patients.

Résumé Cent dix huit pieds avec hallux valgus arthrosique ou hallux rigidus, opérés par la méthode de Keller-Brandes ont été examinés après un délai moyen de 9,1 ans (1,7–24,3). L'amélioration de l'hallux valgus était en moyenne

de 40 à 23 degrés. Dans les hallux valgus l'amélioration de la mobilité était constaté quand le traitement post-opératoire était une extension par broche de Kirschner plutôt qu'une immobilisation par brochage axial. Les patients opérés pour hallux valgus avaient moins de douleurs quand était utilisé un brochage axial et ceux opérés pour hallux rigidus en avaient moins quand était utilisé une extension. Plus de 66,7% des patients étaient satisfaits ou très satisfaits des résultats cosmétiques de l'opération. Les patients avec hallux valgus étaient plus satisfaits quand était utilisée le brochage axial et les patients avec hallux rigidus étaient plus satisfaits quand une extension post-opératoire était utilisée. Nos bons résultats sont comparables avec ceux d'autres séries et confirme le succès de la résection arthroplastie de Keller-Brandes pour les hallux valgus avec arthrose de la première métatarsophalangienne chez les patients âgés peu demandeurs et pour les hallux rigidus chez les patients âgés peu actifs.

Introduction

Hallux rigidus means a limitation of motion of the metatarsophalangeal joint of the great toe, most often caused by degenerative osteoarthritis of the first metatarsophalangeal joint. Hallux valgus is a complex deformity of the first ray with a valgus angle of the first metatarsophalangeal joint of more than 15–20°. A pronation of the great toe usually results when the valgus angle exceeds 30–35°.

Pain and disability can accompany Hallux rigidus and Hallux valgus and may lead to surgery. Many different operations have been recommended for the treatment of Hallux rigidus (for example cheilectomy, extension osteotomy of the proximal phalanx or arthrodesis), while more than 150 different operations are recommended for the

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treatment of the Hallux valgus (for example distal soft tissue procedures, proximal or diaphyseal or distal osteotomies of the first metatarsal or arthrodesis).

For less active and less demanding older people with Hallux valgus or Hallux rigidus the Keller-Brandes resection arthroplasty may be an alternative. It combines resection hemiarthroplasty of the first metatarsophalangeal joint with removal of the medial eminence of the first metatarsal. The principle was first described by Riedel in 1886. It became popular for Hallux valgus surgery after Keller's publications in 1904 and 1912 [8, 9]. In Germany it was recommended by Brandes [1] in the 1920s as a correction method for Hallux rigidus.

Around the end of the nineteenth century a better understanding of foot problems and new surgical methods raised the questions about the validity of the Keller Brandes operation [6]. This discussion continues.

Numerous modifications have been described with respect to the amount of resection, a cerclage fibrex, removal of the fibular sesamoid, lateral displacement of the first metatarsal and other soft tissue or bony procedures. One or two Kirschner wires normally secure the corrected position and the sometimes interpositioned capsule. The Kirschner wires can transfix the great toe and the first metatarsal, or they may be used for distraction in a plaster.

While numerous publications have shown that surgery can result in a satisfactorily well-aligned hallux with better motion, relief of pain and some improvement in the variety of shoes that can be worn, failed Keller resection arthroplasty is not uncommon. A number of the typical complications associated with Keller resection arthroplasty include recurrent valgus deformity, cock-up deformity or instability or secondary degenerative changes. These may be difficult problems for the surgeon involved because options for salvage are limited [12]. In the past little attention has been paid to the influence of the aftertreatment on these complications.

It is the aim of this study to describe the influence of two different aftertreatments.

Materials and method

A total of 217 feet with Hallux valgus and 71 feet with Hallux rigidus were operated by the Keller-Brandes method and reviewed.

Candidates for the Keller procedures were patients over 50 years of age with severe Hallux valgus, intermetatarsal angles of 14° or less, degenerative osteoarthritis of the first metatarsophalangeal joint and pain over the medial eminence with any shoe worn or Hallux rigidus with marked degenerative changes.

The technique used consisted of an initial straight midline medial incision 1 cm proximal to the interphalangeal joint of

the hallux to the junction of distal and middle thirds of the first metatarsal. This was followed by preparation of a proximally based medial capsule flap, resection of the medial eminence at the sagittal groove, removal of the proximal phalanx at the metaphyseal-diaphyseal junction, which usually constitutes the proximal third of the phalanx, release of the basilar fragment on the lateral side, evaluation of the alignment and cerclage fibrex. The Kirschner wire was placed for transfixation up to the middle of the first metatarsal or distraction with another wire in the distal phalanx of the hallux (Figs. 1, 2, 3). The decision was made at the surgeon's discretion. We carried out no modifications such as the removal of the fibular sesamoid or lateral displacement of the first metatarsal because we had no intermetatarsal angle of 15° or higher. The wound was then closed. We used a plaster in the distraction group and only firm-soled shoes in the transfixation group. The wires remained in place for 21 days after which all the patients received firm-soled shoes for the next 3 weeks and night splints for the first 3 months following operation.

Because of the possibility of aftertreatment with Kirschner wire distraction or axial Kirschner wire transfixation, the study cohort was divided into four subgroups for evaluation of the results:

- Group 1: Hallux valgus treated with extension (Hv/Ex);
- Group 2: Hallux rigidus treated with extension (Hr/Ex);
- Group 3: Hallux valgus treated with axial Kirschner wire (Hv/Ki);
- Group 4: Hallux rigidus treated with axial Kirschner wire (Hr/Ki).

In 162 of the feet treated, 254 claw toes were treated during the same operation. In all cases the reason for the operative intervention was the hallux.

The patient's records were retrospectively evaluated using a standardised questionnaire to evaluate the patient population and demographics. X-rays were evaluated before the operation, after removal of the Kirschner wire – within

Fig. 1 K- wire distraction after Keller-Brandes arthroplasty

Fig. 2 Distraction after Keller-arthroplasty

3 months of the operation – and at time of the follow-up examination. Only dorsiplantar X-rays of the foot with weightbearing in a standing position were used.

In addition, all patients were invited to an additional clinical and radiological examination. The following parameters were selected to evaluate clinical success: pain, worn shoes, walking ability, function, range of motion, hallux valgus angle. Again only dorsiplantar X-rays with weightbearing were used. A total of 118 feet treated by the Keller-Brandes method were re-examined by the author. Of these, 43 feet were placed in group 1, 14 in group 2, 49 in group 3 and 12 in group 4.

The mean clinical and radiological follow-up was 9.1 years (range: 1.7–24.3). X-rays of an acceptable quality were unavailable for 41 feet, and these feet were excluded from the study.

All patients participating in the study were sent a questionnaire which contained questions on the patient's satisfaction with the cosmetic results, mobility, function and the operation in general, together with complications and

any re-operation. Questionnaires were returned for 113 feet that had been treated by the Keller-Brandes method: group 1, 58 questionnaires were returned; group 2, 16; group 3, 33; group 4, six questionnaires. All other questionnaires were either not deliverable by mail, or the patient had already died from causes unrelated to the operation.

The results were classified by the Burckhardt and Abbühl method [3], as shown in [Appendix](#).

Results

Epidemiological data

A total of 288 feet were treated by the Keller-Brandes method: 149 right and 139 left great toes. Of these, 217 great toes were operated on for a Hallux valgus. Aftertreatment was carried out by distraction of the great toe in 91 cases and by axial Kirschner wire transfixation in 126 cases. A Hallus rigidus was operated on in 71 cases, followed by distraction in 33 cases and by an axial Kirschner wire in 38. More women than men underwent

Fig. 3 K-wire transfixation after Keller-Brandes arthroplasty

surgery: 86% of the Hallux valgus group were women, while 72% of the Hallux rigidus group were women. The age of most patients at the time of surgery was between 51 and 60 years ($n=100$). At the time of surgery, the diagnosis of Hallux valgus or rigidus had been made for between 6 months and 24 years (Mean for group 1: 3.3; group 2: 5.5; group 3: 3.4; group 4: 2.8 years).

Preoperative clinic

Pain was the reason for surgery in 97% of the feet treated, with the main localisation of pain being the first metatarsophalangeal joint in 75% of the feet and the medial eminence in 25%. Additionally, in the Hallux rigidus group, stiffening of the metacarpophalangeal joint of the big toe was frequently cited as the reason for surgery: 21% of the cases in Group 2 and 34% of the cases in Group 4.

Preoperative X-ray

A preoperative X-ray was available for 247 of the 288 feet with degenerative forefoot changes: 91 feet in group 1, 33 in group 2, 126 in group 3 and 38 feet in group 4.

Marked degenerative changes of the first metatarsophalangeal joint were present in all patients. The mean preoperative Hallux valgus angle in group 1 was 40.5° (SD: ± 11.2); in group, 3 39.1° (SD: ± 11.3); in group 2, 14.7° (SD: ± 6.4); in group 4, 15.5° (SD: ± 10.1).

The mean preoperative joint space of the metatarsophalangeal joint of the big toe in group 1 was 1.7 mm (SD: ± 0.5); in group 3, 1.8 mm (SD: ± 0.6); in group 2, 1.2 mm (SD: ± 0.7); in group, 4 1.4 mm (SD: 0.4).

Postoperative X-ray

A postoperative X-ray was available for 259 feet: 90 feet in group 1, 29 in group 2, 106 in group 3 and 34 feet in group 4.

The mean postoperative Hallux valgus angle in group 1 was 8.7° (SD: ± 7.9); in group 3, 11.9° (SD: ± 6.7); in group 2, 2.2° (SD: ± 4.1); in group 4, 6.7° (SD: ± 6.4).

The mean extent of resection was 10 mm, with a minimum of 2 mm and a maximum of 18 mm.

The mean joint space of the metatarsophalangeal joint of the great toe in group 1 was 9.1 mm (SD: ± 3.9); in group 3, 6.6 mm (SD: ± 2.8); in group, 2 9.2 mm (SD: ± 3.2); in group, 4 7.9 mm (SD: ± 3.4).

Postoperative complications occurred in 19 of the 288 feet (7%). The most frequent complication was a superficial infection ($n=12$; 4% of all cases). The group of patients with Hallux valgus and Kirschner wire distraction experienced the most complications. Table 1 shows the number of complications with respect to the different subgroups. Sixteen feet (6%) still required orthopaedic shoes following surgery.

Questionnaire

The subgroup “Hallux valgus treated with Kirschner wire transfixation” had the best results with respect to pain relief. Of the feet operated on in this group, 81.8% functioned without pain postoperatively. Patients with former Hallux rigidus and postoperative Kirschner wire transfixation often reported some degree of pain. Within this latter group, the remaining postoperative pain was rated mild, but was still present in 83.3% of the cases. The distribution of postoperative pain is shown in relation to the individual subgroups in Table 2.

When all four groups were considered at a whole, the percentage of satisfied and very satisfied patients was greater than 66.7%. The groups of patients with Hallux valgus and treated only with Kirschner wire fixation again reported the best results; however, 33.3% of patients with Hallux rigidus and postoperative Kirschner wire fixation were dissatisfied with the postoperative cosmetic result. In four cases the reason for this dissatisfaction was pain due to false position of the great toe, in three cases there was a relapse without pain or the hallux was too short and one hallux was overcorrected in a varus position. The distribution of satisfaction within the individual groups with respect to the cosmetic result is shown in Table 3.

In all four groups, more than the 80% of patients were satisfied with the postoperative range of motion of the metatarsophalangeal joint I. Only 12.5% of the patients with Hallux rigidus in group 2 and 16.7% of the patients in group 4 were dissatisfied.

A total of 95.6% of the patients would recommend this procedure to others.

Clinical follow-up examination

Of the 118 feet examined during the follow-up examination, 14 were still painful. While none of the feet treated for Hallux valgus using Kirschner wire transfixation was painful, 80% of the patients treated with distraction still had pain, especially plantar and dorsal of the metatarsophalangeal joint of the great toe. In the Hallux valgus group, the mean values for dorsal extension and plantar flexion were better after treatment with distraction. The mean value for dorsal extension was 33° in group 1 (with distraction) and 27.1° in group 3 (with Kirschner wire fixation). The mean value for plantar flexion was 28.4° in group 1 (with distraction) and 21.8° in group 3 (with Kirschner wire fixation). However, the only unstable joints were also found in the group treated by distraction. The number of great toes without floor contact or with pronation were almost equally distributed between groups 1 (40%) and 3 (30%).

In the Hallux rigidus subgroups, the feet treated with transfixation suffered from pain more often than the feet

Table 1 Number of complications in the 288 feet operated on among the various groups

Group and technique ^a	Deep infection	Superficial infection	Nerve damage	Oedema	Total
Group 1 (Hv/Ex)	3	7	0	1	11 (12%)
Group 2 (Hr/Ex)	0	2	0	1	39 (%)
Group 3 (Hv/Ki)	0	2	1	1	4 (3%)
Group 4 (Hr/Ki)	0	1	0	0	1 (3%)
Total	3 (1%)	12 (4%)	1 (1%)	3 (1%)	19 (7%)

^aHv, Hallux valgus; Ki, axial Kirschner wire; Hr, Hallux rigidus; Ex, extension

treated with distraction. At the time of the follow-up examination, no pain was reported in 93% of the feet of group 1 (with distraction); this figure was only 83% in group 2 (with Kirschner wire fixation).

The mean value for dorsal extension in group 2 (with distraction) was 31.4°; this was 30.2° in group 4 (with transfixation). The mean value for plantar flexion was 27.5° in group 2 (with distraction) and 21.8° in group 4 (with transfixation). The only completely stiff hallux was found in group 4. Aftertreatment with distraction showed a slightly better range of motion of the metatarsophalangeal joint of the hallux at follow-up. However, there were also 14% unstable joints in the group treated with distraction. No unstable joint was found following transfixation. In group 2, 72% of the toes had floor contact; in group 4 this was only 50%.

X-ray at follow-up

The mean Hallux valgus angle at follow-up in group 1 was 23.5° (SD: ±9.4); in group 3, 23.3° (SD: ±11); in group 2, 7.4° (SD: ±5.1); in group 4, 8.4° (SD: ±12.5). The mean joint space in the metatarsophalangeal joint I at the time of the follow-up examination was 3 mm (SD: ±1.2) in group 1, 2.1 mm (SD: ±1) in group 3, 3.2 mm (SD: ±1.5) in group 2 and 3 mm (SD: ±1.4) in group 4.

Overall results

Of the patients treated, 74% of those with Hallux valgus and aftertreatment with distraction and 76% of those with Hallux valgus and aftertreatment with transfixation showed very good and good results according to the classification of Burckhardt and Abbühl. In the Hallux rigidus subgroups, 88% had very good and good results when they were

treated with distraction; this value was 83% when the joint was only transfixed.

Discussion

Numerous surgical procedures are available for the treatment of Hallux valgus or Hallux rigidus. The choice of any one of these depends on the severity of the disease, the activity level and expectations of the patient. Keller arthroplasty is reserved for low-demand patients [7]. For younger and active patients, other joint preserving procedures or an arthrodesis are preferable [20].

The main reason for performing this arthroplasty is pain in 70–100% of the cases [13, 16]. This is supported by our study cohort: 97% of our patients had pain. Pain can usually be greatly improved by this operation. Leonhardt [11] reported of 73.7% painless feet after 175 Keller-Brandes operations, while Donley et al. reported 76% painless feet after 50 operations [4]. In our study, 88.1% of the feet were painless following the operation. This effect was especially evident in the group Hallux valgus with Kirschner wire transfixation: not one patient complained of pain at the time of follow-up. The primary goal of the surgery had thus been reliably attained.

However, it is often claimed that this surgical method sacrifices the metatarsophalangeal joint and that the patient is mutilated without adequate reason.

In our study population 3% of the patients treated with Kirschner wire transfixation and 9.3% of the patients treated with distraction after Hallux valgus surgery were not satisfied with the cosmetic result. When surgery was performed for Hallux rigidus, dissatisfaction with the cosmetic for surgery was even higher: 18.7% of patients treated with distraction were dissatisfied, as were 33% of those treated with the Kirschner wire transfixation. A literature search revealed that cosmetic results are always more poorly rated than the function attained and postoperative freedom from pain. Breitenseher et al. [2] reported that more than 90.8% of their patients reported good and very good function and pain results, but only 71.9% reported good and very good cosmetic results. Kleinod [10] reported 96% good and very good results for function but only 90.4%

Table 2 Freedom from pain at follow-up

	No pain
Group 1 (Hv/Ex)	79.5%
Group 2 (Hr/Ex)	92.9%
Group 3 (Hv/Ki)	100%
Group 4 (Hr/Ki)	83.3%

Table 3 Satisfaction in the individual groups with the cosmetic appearance at the time of follow-up

	Very good	Good	Moderate	Poor
Group 1 (Hv/Ex)	20 feet (34%)	23 feet (40%)	11 feet (19%)	4 feet (7%)
Group 2 (Hr/Ex)	8 feet (50%)	6 feet (38%)	1 foot (6%)	1 foot (6%)
Group 3 (Hv/Ki)	13 feet (40%)	12 feet (36%)	5 feet (15%)	3 feet (9%)
Group 4 (Hr/Ki)	3 feet (50%)	2 feet (33%)	1 foot (17%)	0 feet (0%)

for the cosmetic result. In 1994 Toma [14] found good and very good functional results in 90.8% of 128 operated forefeet, but only 69% good and very good cosmetic results. Weber [18] achieved only 19% good and very good cosmetic results in his patients, who were all relatively younger; no patient rated the preoperative cosmetic appearance as being better than the postoperative one. The poor result may be explained by the younger age of his patients, who would have higher demands with regard to appearance. The patients of all four of our groups had marked improvement of the Hallux valgus angle. In group 1, the metatarsophalangeal angle was improved to an average of 8.7° postoperative from 40.5° preoperative; in group 3, the improvement was $3\text{--}11.9^\circ$ from 39.1° . During the follow-up period a marked correction loss was detected to an average Hallux valgus angle of 23.5° in group 1 and 23.3° in group 3. Viladot et al. [17] reported improvement of the Hallux valgus angle from preoperative 38.3° to 20.8° at the time of follow-up after 10 years, and the values for Turnbull and Grange [15] were 36° to 21° , also after 10 years. When the mean of the postoperative Hallux valgus angle was compared to that at the time of follow-up, it is evident that the angle deteriorated 3° more in feet treated with distraction than in feet treated with transfixation, but as the initial correction was better in the latter treatment, the different treatments with distraction or Kirschner wire had essentially no impact on the final outcome. The extent of correction by the Keller-Brandes method can thus normally be rated as being good to very good, with few exceptions.

The patients treated only for Hallux rigidus had a Hallux valgus angle of less than 20° in all cases at follow-up. A lasting correction of an average of 7° was attained.

Shortening of the big toe correlates directly with the amount of resection of the proximal phalanx and was the reason not only for poor cosmetic ratings but also for unstable joints and weakened push-off in our patients; a literature search revealed that this is especially true in patients with rheumatoid arthritis [5].

Willkommen [19] found unstable joints in 16% of his patients with a major resection and as much as 34% when two thirds were resected. In our study population with only a one-third resection in most cases, we found 4.5% unstable

joints in group 1 (Hallux valgus with distraction) and 14.3% in group 2 (Hallux rigidus with distraction). Conversely, the average of range of motion for dorsal extension and plantar flexion showed better values for the aftertreatment with distraction. Average dorsal extension in the Hallux valgus patients was 33° in group 1 (with distraction) and 27.1° in group 3 (with Kirschner wire transfixation). The average for plantar flexion was 28.4° in group 1 (with distraction) and 21.8° in group 3 (with Kirschner wire transfixation). This indicates that the regime of aftertreatment may have an influence on the range of motion and even the stability of the metatarsophalangeal joint I after a Keller-Brandes arthroplasty.

Negative Hallux valgus angles occurred postoperatively in all four groups, but these usually corrected themselves to positive values. Only in group 4 was there no spontaneous correction. In the particular case of a Hallux rigidus being corrected by distraction, special attention should be paid to the correct positioning of the hallux after surgery.

The postoperative distraction treatment has a number of advantages following Keller-Brandes arthroplasties for Hallux valgus and Hallux rigidus with respect to the range of motion of the metatarsophalangeal joint. However, this treatment also increases the danger for unstable joints. In Hallux rigidus, the percentage of painful postoperative metatarsophalangeal joints can be reduced by better protection of the distraction gap.

On the basis of the Burckhardt and Abbühl [3] classification of patients treated by the Keller-Brandes method for Hallux valgus, 74% of the results were very good and good when the patients were treated with distraction after surgery and 76% were very good and good when aftertreatment consisted of transfixation. In Hallux rigidus, 88% of the results were very good and good results with postoperative distraction and 83% were very good and good with Kirschner wire transfixation. Burckhardt and Abbühl found similar results [3].

Our results show that the Keller-Brandes procedure is still of value for Hallux valgus and Hallux rigidus in patients with low demands. The aftertreatment with K-wire transfixation or distraction may influence the overall result. The selection of a specific aftertreatment may offer advantages

Appendix

Burckhardt and Abbühl (1991) Classification for Keller-Brandes surgery.

Very good:

No pain, normal shoes, unlimited walking ability, normal function of the great toe, valgus position $<20^\circ$.

Good:

No pain of the great toe, mild metatarsalgia, walking capacity unlimited in good shoes, valgus angle of between 20 and 30° .

Moderate:

Pain of the great toe, slightly limited walking capacity, requires only orthopedic inner soles, valgus angle $>30^\circ$.

Poor:

Considerable pain, walking capacity clearly limited, requires orthopedic shoes, valgus angle unchanged.

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