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Cost effectiveness of different techniques in hallux valgus surgery

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ABSTRACT

Background: Different surgical techniques are available to correct each type of Hallux Valgus (HV) deformity, and all present similar good results. No information is available relative to the cost of each technique compared to their individual success.
Objective: To determine the cost-effectiveness-ratio (CER) of five different techniques for HV.
Methods: We included 245HV surgeries performed in 179 patients. The severity was defined according to radiological parameters. For mild to moderate HV we included the Chevron, Modified-Scarf and Ludloff techniques; for severe HV: either Poscow-osteotomy or Lapidus-arthrodesis fixed with plates or screws. Weighted costs were estimated. CER was expressed in $US dollars per AOFAS-point.
Results: The lowest weighted cost was observed for the Chevron-group, and the highest weighted cost was observed in the Poscow-osteotomy and Lapidus-arthrodesis fixed with plate groups. The AOFAS-score improvement was higher in the Chevron and Modified-Scarf groups. The CER found for Chevron and Modified-Scarf techniques were significantly less than for Poscow and Lapidus-techniques.
Conclusion: Cost-Effectiveness-Ratio was lower, and therefore better, in the groups with mild to moderate deformities operated with Chevron or Modified-Scarf techniques. In severe HV, the three techniques investigated presented similar CER. CER analysis is an additional factor that can be included in the decision making analysis in hallux valgus surgery.

Level of Evidence
Level IV, Retrospective Study

1. Introduction

Hallux Valgus (HV) is a frequent deformity of the forefoot [1] and more than 100 surgical techniques have been described to restore its morphology and function [2–5]. Different surgical techniques have been proposed even for each type of HV deformity. However, with the information available today is not yet possible to select the most appropriate technique for every type of deformity. Decision making algorithm schemes for bunion surgery have been published over 2 decades ago, and they all consider clinical and radiological factors [6]. An additional factor which could be considered is the economical one.

Cost-Effectiveness Analysis (CEA) is a common method of economic analysis applied in orthopaedics, using as an input the monetary units (cost in dollars for example), and for output the clinical outcome (effectiveness) [7] using clinical scores such as the American Orthopaedic Foot and Ankle Society (AOFAS) Score. The ratio between the two parameters is denominated cost-effectiveness ratio (CER) and it is used in this type of analysis. Other economic tool commonly applied in orthopaedics is the Cost-Utility Analysis, which uses quality-adjusted life years (QALY) [7]. Nevertheless QALY is a global measure of the patient health state and is not necessarily associated with the results of HV surgical techniques [8,9].

One advantage of CEA is that it constitutes an additional factor in the decision making process, helpful when the results must be translated into economical benefits, specially in developing countries, and it is a useful tool for preliminary analysis and to establish a baseline proceeding to more complicated economical methods [7]. To our knowledge no studies are available that fully compare costs associated to hallux valgus surgery. An article by Poggio published recently [10] compares the economic costs for all postoperative visits and complications after surgery but no cost

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comparison is performed for the preoperative or intraoperative phase. Our study is the first one which analyzes cost effectiveness relative to hallux valgus surgery in the preoperative and intraoperative phase, adding an estimated cost for expected complications.

The purpose of our study was to describe and compare the cost-effectiveness ratio (CER) of 5 different surgical techniques commonly used in our country to treat HV deformity: Chevron [3,11], Modified Scarf [3] and Ludloff [4] in mild to moderate HV; and Poscow Osteotomy [12,13], Modified Lapidus fixed with Screws [14–16] and Modified Lapidus fixed with Plate and Screws [14,17,18] in Severe HV.

2. Materials and methods

The series analyzed included 179 patients diagnosed with HV, operated between 2009 and 2012 in three private hospitals our country. Trained foot and ankle surgeons performed the surgical techniques according to the severity of the diagnosis, as described in the literature, with the same implant type in each technique. The severity of deformity was classified by radiological criteria: Mild to moderate deformity was defined as deformities with less than 15 degrees of 1–2 intermetatarsal angle (IMA); and severe more than 15 degrees IMA [5]. For mild to moderate deformities, three different techniques were used: Chevron [3,11], Modified Scarf [3], and Ludloff osteotomies [4]; while for severe HV deformities, two different techniques with three different hardware configurations were analyzed: POSCOW proximal osteotomy [12,13], Lapidus arthrodesis fixed with screws [14] and Lapidus arthrodesis fixed with plates [14,17,18].

A total of 245 HV surgeries in 179 patients were included, of which 94% ($n = 169$) were female. Median age was 54 years old (IQR: 18, Range: 14–81). 55.9% ($n = 137$) of the feet presented a severe deformity, of which 80.3% ($n = 110$) were operated with the POSCOW technique, 12.4% ($n = 17$) with Lapidus Arthrodesis fixed with Screws and 7.2% ($n = 10$) with Lapidus fixed with plate. In patients with mild to moderate deformities, Chevron technique was used in 62% ($n = 67$) of cases, Modified Scarf technique in 25.9% ($n = 28$) and Ludloff osteotomy in 12.1% ($n = 13$). Akin osteotomy was added in 18.4% ($n = 39$) of all surgeries: 48.7% ($n = 19$) on POSCOW surgery, 25.64% ($n = 10$) on Modified Lapidus arthrodesis fixed with screws, 15.4% ($n = 6$) on Modified Lapidus fixed with screws and plates and 10.3% ($n = 4$) on Modified Scarf surgery. No Akin osteotomy was used in the Chevron group. The hardware used for each surgery was: one 2.0 screw for Chevron; three 2.0 screws for Modified Scarf, three 2.4 screws for Ludloff; one mini fragment 2.7 locked plate and four 2.7 screws for Poscow; two cannulated 3.5 screws for Lapidus fixed with screws; and one 2.7 mini fragment locked plate and four 2.7 screws for Lapidus fixed with plate and screws. When the Akin osteotomy was used, it was fixed with one 2.0 screw.

2.1. Cost analysis

For cost evaluation, we considered the following: implants, hospital charges, radiographic images, medication use and labor leave period. Table 1 shows the total costs considered in the analysis. The presence of complications involves increased costs for postoperative radiographic images and medical checks; while the need for reoperation involves increased costs for hospitalization, surgical supplies, medical fees, medication, radiographic controls, medical checks and labor rest period. Although complications or reoperations data was not available for the entire series, an estimated cost for these complications was considered globally as a weighted cost. We assigned a complication/reoperation probability of 5/2.5% and 10%/5% in mild to moderate deformity and severe deformity surgeries, respectively [19]. Hospitalization cost was estimated by the average fees of the three clinics where the surgeries were performed. This costs included hospitalization days, operative room use and preoperative tests. Wage loss was estimated by the average earnings of the percentiles 70, 80 and 90 of the population, according to the Survey of Employment and Unemployment in Greater Santiago area, conducted by the Microdata Center of the Department of Economics, University of Chile (Quarterly Employment Report, June 2013).

Table 1
Private costs included in the Cost Effectiveness Analysis.

Surgical techniques	Supplies	Complic/Reoperat prob	W.C. (USD)
Chevron	1 screw 2.0	0.05/0.025	56
Modified Scarf	3 screws 2.0	0.05/0.025	167
Ludloff	2 screws 2.4	0.05/0.025	162
POSCOW proximal	Plate + 5 screws	0.1/0.05	1.910
Modified Lapidus with screws	2 screws	0.1/0.05	130
Modified Lapidus with screws and plates	Plate + 5 screws	0.1/0.05	1.975

Hospital costs	Item	*n*/%	W.C. (USD)
Hospitalization	Hospitalization days	2	2.543
Surgical room	Operating room use		
Test	Pre-surgical Testing		
Medical fees	Surgeon	65%	2.096
	Anesthetist	16%	
	Second Surgeon	13%	
	Surgeon's Assistant	6%	

Drugs	Daily dose (mg)	Duration (days)	W.C. (USD)
Ketorolac	30	10	384
Paracetamol	300	10	
Tramadol extended release	150	SOS	
Cephadroxil	1000	5	
Rivaroxaban	10	21	

Radiographic images	Period	*n*	W.C. (USD)
Foot Radiography	Pre-surgery	1	300/349*
	Post-surgery (without complication)	2	
	Post-surgery (with complication)	5–7	
	Post-surgery (with reoperation)	2	

Medical checks	Period	*N*	W.C. (USD)
	Pre-surgery	2	460/520*
	Post-surgery (without complication)	3	
	Post-surgery (with complication)	9	
	Post-surgery (with reoperation)	12	

Wage loss	Measurement	*N*	W.C. (USD)
Laboral leave period	Weeks post surgery	6	2409

W.C.: Weighted Cost (USD, currency 2013). * Weighted Cost by Complication/Reoperation probability.

2.2. Effectiveness analysis

The improvement between pre and post surgery AOFAS score was used to measure the effectiveness obtained with each surgical technique. AOFAS score assigns 40 points to pain, 45 points to function and 15 points for alignment. Individual AOFAS scores, before and after surgery, were available for every technique except Lapidus fixed with screws, which was therefore not included in the final comparison. The AOFAS scores post-surgery were measured

at the time of medical discharge in all cases, on average, 1.4 years postoperatively.

2.3. Cost-effectiveness analysis

For every surgical technique we obtained the CER. This ratio allowed us to compare HV surgeries, according to severity, in terms of cost effectiveness ($US dollars spending per each AOFAS point improvement). The CER was obtained dividing the weighted cost (in dollars) by the clinical effectiveness (improvement in AOFAS points) for each surgical technique.

2.4. Statistical analysis

Descriptive statistics was performed for the complete series. The Shapiro Wilk Test was used to analyze the normality of data in each surgical technique. The Kruskal-Wallis test was used to perform multiple comparisons between groups, adjusting the *p*-values with the Bonferroni correction. The adjusted *p*-value for significance between groups was 0.0025.

3. Results

The weighted cost for the implants depending on the different surgical techniques used is presented in Table 1. The least expensive one was for the Chevron technique, $USD 53. The most expensive one corresponded to the Lapidus fixed with plate and screws technique, $USD 1795. Table 2 shows all costs (Medication, hospitalization, medical fees and checks, wage loss, implants) considered in different scenarios: without complications, with complications without a new surgery and with revision surgery. The cost of a hallux valgus surgery, not considering implants, was $USD7586/15584, uncomplicated/complicated with revision surgery, respectively.

The effectiveness (AOFAS improvement points/% of improvement) for each technique is presented in Table 3, where Chevron showed an effectiveness of 43.6 points/84.8%, and Lapidus fixed with plate and screws improved 38.3 points/75.0%. When compared statistically, age was used as an adjustment variable, as Poscow and the Lapidus fixed with plate groups were significantly older than the group operated with the Chevron technique (see Table 4). The Lapidus fixed with screws group had to be eliminated from this analysis, as the series was not complete with values. After age adjustment, groups 1 (Chevron) and 2 (Modified Scarf) were more effective clinically ($p < 0.025$), compared against the rest of the groups. Fig. 1 shows the box plot for the groups studied, and Table 5 presents the data for the statistical comparison.

The CER for every surgical technique is shown in Table 6. The Lapidus fixed with screws group had an average CER of 273, but no comparison can be performed against the rest of the groups. The Chevron technique showed the smallest CER, with 171 USD/AOFAS point, and the Poscow technique showed the highest CER value, which corresponded to 289. When compared statistically, the Chevron and Modified Scarf technique were more cost effective than the Poscow or Lapidus technique ($p < 0.0025$); the Ludloff technique was more cost effective than the Poscow technique ($p < 0.0025$); the rest of the comparisons specifically within the mild to moderate group or within the severe group showed no statistically significant differences (see Table 7 and Fig. 2).

Table 2
Costs included in different scenarios.

Item	Cost 1 ($USD)	Cost 2 ($USD)	Cost 3 ($USD)
Radiography	252	588	756
Medication	366	366	731
Hospitalization	2.422	2.422	4.844
Medical fees	1.996	1.996	3993
Medical checks	400	720	960
Wage loss	2.150	2.150	4.300
	7.586	8.242	15.584
Chevron	53	53	106
Modified Scarf	159	159	319
Ludloff	154	154	309
POSCOW proximal	1.736	1.736	3.473
Modified Lapidus with screws	118	118	236
Modified Lapidus with screws and plates	1.795	1.795	3.591

Cost 1: No complication or reoperation; Cost 2: Complication present, without reoperation; Cost 3: Complication present, with reoperation.

Table 3
Summary of effectiveness for different surgical techniques, expressed in AOFAS points of improvement.

Surgical techniques	Difference AOFAS (points/%)
Chevron	43.6/84.8
Modified Scarf	48.6/99.2
Ludloff	33.0/62.8
POSCOW proximal	37.2/77.5
Modified Lapidus with screws	32.7/70.6
Modified Lapidus with screws and plates	38.3/75.0

Table 4
Comparison of age between groups. Values shown as difference in mean age, p value for significance. Group 1 corresponds to the Chevron technique, Group 2 to the Modified Scarf technique, Group 3 to the Ludloff technique, Group 4 to the Poscow technique, and Group 6 to the Lapidus arthrodesis fixed with plate technique.

Groups	1	2	3	4
2	8.46002, 0.073			
3	5.33639, 1.0	−3.12363, 1.0		
4	12.1693, 0.000	3.70929, 1.0	6.83292, 0.976	
6	18.5672, 0.001	10.1071, 0.492	13.2308, 0.244	6.39785, 1.0

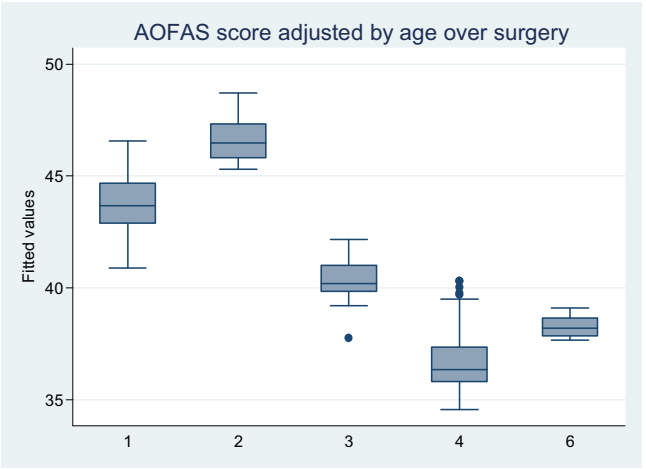

Fig. 1. Box plot of AOFAS difference in score for every surgical technique. Numbers in the *x*-axis refers to the different groups analyzed, i.e. 1: Chevron; 2: Modified Scarf; 3: Ludloff; 4: Poscow; 6: Lapidus fixed with plates.

Table 5
Difference in AOFAS score adjusted by age. Group 4 was used as a constant. Group 1 is represented as TCx1, Group 2 as TCx2, Group 3 as TCx3, Group 6 as TCx6.

Difference score	Coef	Std. error	*t*	*P*-value	95% Confidence	Interval
TCx1	5.884047	1.849309	3.18	0.002	2.237943	9.530151
TCx2	9.485096	2.332961	4.07	0.000	4.885423	14.08477
TCx3	2.940395	3.214085	0.91	0.361	−3.396505	9.277296
TCx6	2.122787	3.605054	0.59	0.557	−4.984949	9.230523
Age	−.0899482	.0541705	−1.66	0.098	−.1967509	.0168545
cons	41.754	3.212825	13.00	0.000	35.41959	48.08842

Table 6
Summary for CER by categories of type of surgery. *N*: number of values, Min: minimum, P25: percentile 25, Max: maximum.

Surgery type	*N*	Min	P25	P50	P75	Max
Chevron	67	126.8958	164.9645	171.838	217.0585	749.8386
Scarf	28	137.0464	150.6398	177.8688	194.4147	835.9832
Ludloff	13	174.0538	174.0538	194.2926	219.8574	464.1434
Poscow	93	175.5501	243.3762	289.4204	382.4484	823.7349
Lapidus	10	192.3843	244.8528	279.879	326.4704	468.414
Total	211	126.8958	177.8688	218.5419	299.2645	835.9832

4. Discussion

Different surgical techniques have been published over many years, each one achieving excellent results, even with AOFAS (American Orthopedic Foot and Ankle Society) scores around 90 points. The excess of techniques indicates that no single operation is perfect, and none will address all cases. Determining which to use can be difficult [3] and more information when choosing the appropriate technique is necessary. One additional factor could be the economical one. Most orthopaedic studies which address the issue of cost-effectiveness deal with total hip arthroplasty [20,21,23] knee arthroscopy, [23] anterior cruciate ligament reconstruction [24,25] and total ankle replacement. [25] In the literature, only two articles were found which deal with cost effectiveness in hallux valgus surgery. One is related to the benefits of an ambulatory surgery program with no evidence relative to any particular technique. [28], and the other one was already commented on and does not include any evaluation on preoperative or intraoperative costs [10]

To our knowledge, this is the first article dealing with cost-effectiveness of different techniques in HV surgery.

Osteotomies are mostly used to correct HV deformities, and different techniques are used depending on the severity of the deformity [28]. Pinney showed in 2006 in a survey among US foot and ankle surgeons [29] that for mild deformities (intermetatarsal angle of 11 degrees and hallux valgus angle of 22 degrees) most surgeons chose a distal chevron osteotomy, adding an akin osteotomy in 10% of the cases. The same author showed that for severe hallux valgus cases, the choice was not so clear, as approximately half of the respondents chose a metatarsal osteotomy (e.g. ludloff, proximal crescentic, proximal chevron), 25% chose a first metatarsophalangeal joint arthrodesis and 25% a lapidus procedure [29]. Using these information we decided to analyze some of the procedures mentioned in the literature for hallux valgus treatment and in use in our country, and divided them either as techniques used for mild to moderate deformities (Chevron, Modified Scarf, Ludloff) or for severe deformities (Poscow, Lapidus arthrodesis fixed with screws or plates) [30].

Regarding costs, the chevron technique showed the smallest percentual cost of the implant associated with the surgery, as the implant represented 0.7% of the total surgical cost (53/7639 dollars). For the Ludloff technique, the implants represented only 1.5% of the total surgical cost. For the techniques using plates and screws, the Poscow and Modified Lapidus technique implants represented 18.6% and 19.1% of the total surgical cost (1736/9323 and 1795/9382 dollars, respectively). This difference in implant cost clearly will affect the final Cost Effectiveness Rate, and thus makes more difficult to compare their final CER. Although not well known in the literature, it is well mentioned that some techniques are better suited for mild to moderate deformities, and some others to severe cases [28]. Severe hallux valgus cases are more difficult technically to correct, and as generally more unstable osteotomies are recommended as treatment, more expensive the implants are (e.g. mini fragment locked plates). This rationale would justify an increased implant cost in severe cases, although no information is

Table 7
CER median values comparison for each technique. Corresponding letters indicate statistically significant difference between groups. Significance set at $p < 0.025$.

Surgery Type	P50	$P < 0.025$
Chevron	171.838	A
Modified Scarf	177.8688	B
Ludloff	194.2926	C
Poscow	289.4204	abc
Lapidus	279.879	ab
Total	218.5419	

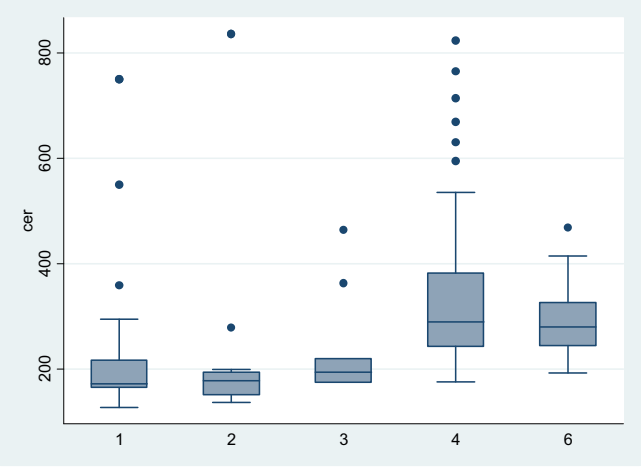

Fig. 2. Box plot of CER values for every surgical technique. Numbers in the *x*-axis refers to the different groups analyzed, i.e. 1: Chevron; 2: Modified Scarf; 3: Ludloff; 4: Poscow; 6: Lapidus fixed with plates.

available which supports this premise. We will comment on this issue when analyzing the differences in CER.

Analyzing effectiveness, and adjusting by age, the most effective techniques were the Chevron ($p = 0.002$) and Modified Scarf techniques ($p = 0.000$), achieving this last technique a better clinical effectiveness. Care has to be taken when analyzing this result, as it does not necessarily reflect that the mentioned techniques are better than the other ones. Their indication reflects surgeon's experience and comfort with a certain technique and not necessarily a better option. We have presented the need to choose surgical techniques depending on their correction capacity, and in doing this, a more stringent treatment protocol was designed [30]. Despite our finding, there is no strong evidence showing better clinical results of Scarf osteotomy compared to Chevron. Deenik et al. [31] in a prospective randomized study reported no statistical differences in hallux valgus angle (HVA) and intermetatarsal angle (IMA) between Scarf and Chevron osteotomies in mild to moderate HV. Subsequently, Smith et al. [11] conducted a systematic review and meta-analysis comparing both Chevron and Scarf osteotomies, reporting only an increase of 0.88 degrees in IMA correction in favor of Scarf osteotomy compared to Chevron osteotomy. This IMA difference does not explain any difference in effectiveness between Scarf and Chevron techniques. In fact, no clinical effectiveness difference has been reported between these two techniques, showing AOFAS score improvements close to 40 points irrespectively [2]. Regarding Ludloff effectiveness, it was significantly lower than Chevron or Modified Scarf, and comparable to the techniques used for severe hallux valgus. This somehow unexpected low effectiveness could be explained by a compromised mechanical stability which could in turn translate into less clinical satisfaction. Less mechanical stiffness has been shown in Ludloff sawbone models compared to Scarf or other techniques [32,33]. Clinically better AOFAS scores have been reported for Scarf osteotomies when compared against Ludloff [34], but no clear reason exists to explain this lower clinical effectiveness. A lesser clinical effectiveness in the severe deformity group was expected to occur, as severe hallux valgus cases represent a bigger challenge technically. As mentioned in the previous lines, the clinical effectiveness of the Poscow and Lapidus groups were comparable to the Ludloff group ($p > 0.3$). Analyzing mechanical stability, if proximal procedures are performed, either osteotomy or arthrodesis, the use of plating constructs has been shown to provide increased stability compared with screw only constructs. Varner et al. [35] using fresh frozen cadaveric feet found that plate fixation provided approximately twice resistance before disruption of the metatarsal osteotomy under cyclic loading conditions. Recently, Smith et al. [36] performed a mechanical analysis comparing two constructs, locking plate versus two cortical screws, to fix oblique osteotomies of metatarsal models made of composite material. Their results evidenced that locking plate construct was able to withstand a greater vertical load before failure than the two screws construct [36]. We think that an increased mechanical stability given by a locked construct could provide less pain, edema and/or other symptoms postoperatively, and consequently, a better clinical satisfaction compared to less stable constructs.

Cost Effectiveness Ratio (CER) was obtained for the 6 different constructs, but it was not possible to include them all in the statistical comparison due to incomplete data in the Lapidus fixed with screws group, which adds a bias to the study. Nevertheless, important information was obtained when compared and analyzed. Table 7 and Fig. 2 show how different the CER values were for the mild to moderate groups compared to the severe groups. Statistically speaking, almost all the techniques used for mild to moderate deformities showed lesser CER values than the techniques used for severe deformities, i.e. they were more cost effective. This was true except for the Ludloff technique, which showed a lesser CER than the Poscow technique but not against the Lapidus fixed with plate technique. This is an interesting finding considering the high implant cost used for the Lapidus fixed with plate compared to the three screws used in the Ludloff technique. The explanation lies in the better clinical effectiveness obtained with the Lapidus fixed with plate technique which showed 37 points of improvement versus 33 points of improvement in the Ludloff group. The higher weighted cost of Lapidus fixed with plate was compensated with a better clinical effectiveness, achieving a statistically similar CER value than the Ludloff procedure. In our study an initial high weighted cost of Poscow proximal osteotomy or Lapidus fixed with plate and screws techniques may be compensated by a better clinical outcome with less pain and better overall function, delaying perhaps future recurrence or other complications which may reduce quality of life in the future. Therefore, the use of expensive osteosynthesis components could be justified if they prove to decrease failure rate, idea which has been published in orthopedics [35,36], but not specifically related to forefoot surgery. We are currently conducting a study to gain information about the possible contribution of a locking implant on clinical satisfaction.

The major limitation of our study is that it applies only to the population studied. It cannot be extrapolated to other techniques, deformities or countries. A multicenter study would be needed in order to provide a better understanding and make it applicable to more groups. We included only some of the surgical techniques available for hallux valgus treatment, and some of them have regional differences, and thus are difficult to be compared against the same technique developed in a different orthopedic center. Nevertheless, it is the first study of its nature and we think it adds information to our decision making process when analyzing hallux valgus deformities. Of great interest is the fact that expensive surgeries appear to provide similar CER values than least expensive ones, which can only be explained by a better clinical result. This is matter of study and no definitive conclusion can be made. Another limitation relates to the use of weighted costs using theoretical values of complications and not the complication and reoperation rates of the case series. We decided to use published values of complications or reoperations in order to overcome potential bias in our data, as different follow-up periods were included and different orthopedic surgeons with various postoperative protocols and data recording systems were included. Other limitations include confounding factors such as Akin osteotomy use, age of patients, level of satisfaction or pain perception, validity of AOFAS score, comorbidities associated to HV deformity, and wage loss. In our series, Akin osteotomy was used in 18,4% of all surgeries. For the authors, Akin osteotomy is indicated not only for interphalangeal hallux valgus but also to aid in the correction of metatarsophalangeal soft tissue balance after metatarsal correction. Thus, its use is biased by surgeon preference and almost impossible to analyze in relation to its contribution to the effectiveness of any particular technique. Regarding age, a difference was found between groups as already stated, where group 1 (Chevron) was statistically younger than groups 4 and 6 (Poscow and Lapidus fixed with plates groups). This limitation was included in the analysis adjusting the AOFAS score improvements by age. Regarding AOFAS score, it is the most widely used clinical outcome tool for foot and ankle. Although its validity, reliability or responsiveness for HV has been questioned by some reports [1,37], we used it because it was readily available in our series and it is extensively used in daily clinical practice for foot and ankle studies. New studies should use validated clinical scores, which incorporate quality of life measures. Relative to comorbidities, smaller toes deformities and metatarsalgia were also present in the complete series but not included in a multivariate analysis which is another drawback for this study. Finally, wage loss due to labor rest period was determined from average values for the whole group, as

the data was incomplete for the complete series and no specific data was available to compare between mild to moderate or severe hallux valgus deformity cases.

Cost effectiveness analysis has become increasingly important in orthopaedics in the last decade [7]. Our study is the first report describing cost-effectiveness of different surgical techniques for HV. This information is useful in the decision making process and effective allocation of the resources. Although our sample comprises a small number of patients and perhaps the results cannot be extrapolated to other latitudes, the techniques that were analyzed are some of the most common published and used in other countries [29], and therefore we think it is useful information whenever resources have to be restricted or justified.

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References

[1] Chen L, Lyman S, Do H. Validation of Foot and Ankle Outcome Score for hallux valgus. Foot Ankle Int 2012;33:1145–55. http://dx.doi.org/10.3113/FAI.2012.1145.
[2] Deenik AR, de Visser E, Louwerens J-WK. Hallux valgus angle as main predictor for correction of hallux valgus. BMC Musculoskele Disord 2008;9(1):70. http://dx.doi.org/10.1186/1471-2474-9-70.
[3] Robinson AHN, Limbers JP. Modern concepts in the treatment of hallux valgus. J Bone Joint Surg Br 2005;87(8):1038–45.
[4] Sammarco VJ. Surgical correction of moderate and severe hallux valgusproximal metatarsal osteotomy with distal soft-tissue correction and arthrodesis of the metatarsophalangeal joint. Instr Course Lect 2008;57:415–28.
[5] Schuh R, Willegger M, Holinka J. Angular correction and complications of proximal first metatarsal osteotomies for hallux valgus deformity. Int Orthop 2013;37(9):1771–80. http://dx.doi.org/10.1007/s00264-013-2012-4.
[6] Mann RA. Decision making in bunion surgery. Iowa Orthop J 1990;10:110.
[7] Vavken P, Bianchi T, In Brief: 1. Cost-effectiveness analyses in orthopaedics. Clin Orthop Relat Res 2011;469(8):2395–8. http://dx.doi.org/10.1007/s11999-011-1873-3.
[8] Dougherty CP, Howard T. Cost-effectiveness in orthopedics: providing essential information to both physicians and health care policy makers for appropriate allocation of medical resources. Sports Med Arthrosc Rev 2013;21(3):166–8.
[9] Dougherty CP, Howard T. PPD-QALY—an index for cost-effectiveness in orthopedics: providing essential information to both physicians and health care policy makers for appropriate allocation of medical resources. Sports Med Arthrosc Rev 2013;21(3):169–73.
[10] Poggio D, Melo R, Botello J, Polo C, Fernández de Retana P, Asunción J. Comparison of postoperative costs of two surgical techniques for hallux valgus (Kramer vs. scarf). Foot Ankle Surg 2015;21(1):37–41.
[11] Smith SE, Landorf KB, Butterworth PA. Scarf versus chevron osteotomy for the correction of 1-2 intermetatarsal angle in hallux valgus: a systematic review and meta-analysis. J Foot Ankle Surg 2012;51(4):437–44. http://dx.doi.org/10.1053/j.jfas.2012.02.016.
[12] Wagner E, Ortiz C, Gould JS, et al. Proximal oblique sliding closing wedge osteotomy for Hallux Valgus. Foot Ankle Int 2013;34(11):1493–500. http://dx.doi.org/10.1177/1071100713497933.
[13] Wagner E, Ortiz C, Keller A. Proximal oblique slide closing wedge metatarsal osteotomy with plate fixation for severe hallux valgus deformities. Tech Foot Ankle Surg 2007;6(4):270–4.
[14] Baravarian B, Ben-Ad R. Contemporary approaches and advancements to the Lapidus procedure. Clin Podiatr Med Surg 2014;31(2):299–308. http://dx.doi.org/10.1016/j.cpm.2014.01.001.
[15] Romain G, Stern R, Assal M. The modified Lapidus procedure. Orthopedics 2008;31(3):230–6.
[16] Schmid T, Krause F. The modified Lapidus fusion. Foot Ankle Clin 2014;19(2):223–33. http://dx.doi.org/10.1016/j.fcl.2014.02.005.
[17] Ellington JK, Myerson MS, Coetzee JC. The use of the Lapidus procedure for recurrent Hallux Valgus. Foot Ankle Int 2011;32(07):674–80. http://dx.doi.org/10.3113/FAI.2011.0674.
[18] Young NJ, Zelen CM, New Techniques. Alternative fixation for the Lapidus arthrodesis. Clin Podiatr Med Surg 2013;30(3):423–34. http://dx.doi.org/10.1016/j.cpm.2013.04.007.
[19] Young NJ, Zelen CM. New techniques and alternative fixation for the Lapidus arthrodesis. Clin Podiatr Med Surg 2013;30(3):423–34. http://dx.doi.org/10.1016/j.cpm.2013.04.007.
[20] Bozic KJ, Morshed S, Silverstein MD. Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics. The case of alternative bearing surfaces in total hip arthroplasty. J Bone Joint Surg Am 2006;88(4):706–14.
[21] Chang RW, Pellissier JM, Hazen GB. A cost-effectiveness analysis of total hip arthroplasty for osteoarthritis of the hip. JAMA 1996;275(11):858–65.
[23] Greene JW, Zois T, Deshmukh A. Routine examination of pathology specimens following knee arthroscopy: a cost-effectiveness analysis. J Bone Joint Surg Am 2014;96(11):917–21. http://dx.doi.org/10.2106/JBJS.M.01083.
[24] Farshad M, Gerber C, Meyer DC. Reconstruction versus conservative treatment after rupture of the anterior cruciate ligament: cost effectiveness analysis. BMC Health Serv Res 2011;11(1):317.
[25] Mather RC, Hettrich CM, Dunn WR. Cost-effectiveness analysis of early reconstruction versus rehabilitation and delayed reconstruction for anterior cruciate ligament tears. Am J Sports Med 2014;42(7):1583–91. http://dx.doi.org/10.1177/0363546514530866.
[28] Trnka H-J. Osteotomies for hallux valgus correction. Foot Ankle Clin 2005;10(1):15–33.
[29] Pinney SJ, Song KR, Chou LB. Surgical treatment of severe hallux valgus. The state of practice among academic foot and ankle surgeons. Foot Ankle Int 2006;27(12):1024–9.
[30] Wagner E, Ortiz C. Osteotomy considerations in hallux valgus treatment: improving the correction power. Foot Ankle Clin 2012;17(3):481–98.
[31] Deenik A, van Mameren H, de Visser E, de Waal Malefijt M, Draijer F, de Bie R. Equivalent correction in scarf and chevron osteotomy in moderate and severe Hallux Valgus: a randomized controlled trial. Foot Ankle Int 2008;29(12):1209–15. http://dx.doi.org/10.3113/FAI.2008.1209.
[32] Castaneda DA, Myerson MS, Neufeld SK. The Ludloff osteotomy: a review of current concepts. Int Orthop 2013;37(9):1661–8. http://dx.doi.org/10.1007/s00264-013-2027-x.
[33] Unal AM. Comparison of screw-fixation stabilities of metatarsal shaft osteotomies: a biomechanical study. Acta Orthop Traumatol Turc 2010;44(1):70–5. http://dx.doi.org/10.3944/AOTT.2010.2209.
[34] Robinson AHN, Bhatia M, Eaton C. Prospective comparative study of the scarf and ludloff osteotomies in the treatment of Hallux Valgus. Foot Ankle Int 2009;30(10):955–63. http://dx.doi.org/10.3113/FAI.2009.0955.
[35] Varner K, Matt V, Alexander J, et al. Screw versus plate fixation of proximal first metatarsal crescentic osteotomy. Foot Ankle Int 2009;30(12):142–9.
[36] Smith K, Lidtke RH, Oliver NG. Mechanical comparison of cortical screw fixation versus locking plate fixation in first metatarsal base osteotomy. J Foot Ankle Surg 2014;53(5):529–33. http://dx.doi.org/10.1053/j.jfas.2014.04.025.
[37] SooHoo NF, Shuler M, Fleming LL. Evaluation of the validity of the AOFAS Clinical Rating Systems by correlation to the SF-36. Foot Ankle Int 2003;24(1):50–5.