Cost-utility Analysis of Vertebroplasty versus Thoracolumbosacral Orthosis in the Treatment of Traumatic Vertebral Fractures

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Abstract

Purpose: To evaluate the cost-utility of Vertebroplasty versus conservative therapy (Thoracolumbosacral orthosis) for treatment of post-traumatic non-osteoporotic and/or non-neoplastic fractures.

Materials and Methods: A prospective, randomized, non-blinded, single-center study was carried out between 2010 and 2013. The study included 99 patients, aged from 18 years to 70 years, suffering from acute non-osteoporotic vertebral fracture. We compared costs and Quality-Adjusted Life Years and assessed the Incremental Cost-Effectiveness Ratio for the two arm groups. Health insurance, patient and societal perspectives are considered.

Results: For health insurance perspective, total cost was €7,267 for the brace group versus €7,365 for the vertebroplasty group (mean difference €75.3; p <0.9). For patient perspective, total cost was €5,303 for the brace group and €3,435 for the vertebroplasty group (mean difference €-1,900.7; p<0.02). For societal perspective, total cost was €13,071 for the brace group and €14,289 for the vertebroplasty group (mean difference €1,165, p <0.36). Differences between groups in QALY were non-significant: 0.01 (95% CI -0.01; 0.04 p=0.5). The Incremental Cost-Effectiveness Ratio was €-12,200 for the health insurance perspective, €159,200 for the patient perspective and €119,466 for societal perspective.

Conclusion: The difference in QALYs does not differ between the two groups, but the vertebroplasty technique results in significantly lower costs from a patient perspective. From societal and health insurance perspectives, we are unable to conclude if the vertebroplasty was more cost-effective than Thoracolumbosacral orthosis.

Keywords

Health economic assessment ; Cost-utility ; QALY ; SF-36 ; SF-6D ; Vertebroplasty ; TLSO ; Clinical practice.

JEL Codes

I18, I19, 033

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1. INTRODUCTION

Traumatic Vertebral fractures represent 14% of verterbral fracture cases and are painful and disabling (Mons et al, 2007). With an annual incidence between 19 and 88/100,000 inhabitants in developed countries, the people most at risk are active male adults with an average age of 45 years.

Vertebroplasty is performed with the injection of polymethyl methacrylate resin within the vertebra in order to stabilize and reduce pain. Initially used for osteolytic vertebral metastases, myeloma and vertebral angioma, this technique has been widely developed (Voormolen and al, 2007; Rousing et al, 2009; Diamond et al, 2006; Diamond et al, 2003; Ploeg et al, 2006 and Masala and al, 2009) especially for osteoporotic fractures even so the results were not unanimous (Rousing et al, 2010; Kallmes et al, 2009; Müller and al, 2010; Zaryanov and al, 2014 and Klazen and al, 2007). However, vertebroplasty for treatment of non-osteoporotic and/or non-neoplastic fractures was poorly supported by the scientific literature (Masala and al, 2009 and Knavel and al, 2009) and therefore remains controversial (Stadhouder and al, 2008; Hossam, 2015 and Maestretti and al, 2014)

Thoracolumbosacral orthosis (TLSO) is the established conservative treatment of choice for the treatment of post-traumatic fractures (Klazen and al, 2007).

If the efficacy of vertebroplasty is proved, the efficiency of the adoption of this alternative in a clinical practice needs to be estimated. The objective of this study was to assess the cost-utility of vertebroplasty compared to TLSO for treatment of non-osteoporotic and/or non-neoplastic fractures.

2. MATERIALS AND METHODS

2.1. STUDY POPULATION

This study was based on the findings of the single-center, non-blinded, prospective, randomized trial conducted between May 2010 and November 2011 at the Hospital of Clermont-Ferrand, France, whose study methods, including the protocol, patient selection and clinical outcome measures were available (ClinicalTrials.gov number, NCT01643395). The study included 99 patients aged from 18 to 70 years suffering from acute (<15 days) Magerl type A non-osteoporotic vertebral fracture including 28% of patients with at least one A3 burst fracture. Exclusion criteria were as follows: - C1 to T4 fractures - associated posterior arch fracture - substantial retropulsion of bony fragments (medullary canal narrowing superior to 50 % in lumbar and 30% in thoracic spine) – neurological complications - head injury with Glasgow Score <15 - long-term painkiller therapy – Local or systemic infection –

suspected or known malignancy- Coagulation Disorders - Contraindication to general anaesthesia - pregnant women – no informed consent obtained.

The protocol was approved by the institutional review board and the local ethical committee. All patients provided written informed consent.

2.2 Procedure

Vertebroplasty:

Procedures were performed by one of the three highly experienced Neuroradiologists having performed more than 300 procedures each under general anaesthesia. An 11 Gauge needle was advanced in the anterior third of the vertebral body. Barium opacified PMMA (Osteopal V Hereus or OsteoFirm William Cook Europe, Bjaeverskov, Denmark) was injected under constant lateral fluoroscopic control. If no injury or complication, patients were discharged the day after procedure. Type and volume of cement injected, cement leakage or procedural complication, were collected after each procedure on the e-CRF.

TLSO:

A tailored thoracolumbosacral orthosis (TLSO) was required to be worn at all times except when lying flat in bed. Compliance in wearing the brace was self-reported by the patient at all relevant follow-up periods. The brace was set to be worn for a period of three months along with rehabilitation and physiotherapy.

2.3 Measurement of utility

Outcome measures were performed before randomization and at 1, 3 and 6 months (16; 18). The primary endpoint was the quality of life, measured by the Short-Form 36 questionnaire (SF-36) at baseline, 1, 3 and 6 months. The SF-36 questionnaire includes 36 questions exploring eight dimensions of quality of life. It has been validated in France. This questionnaire has a limited application in economic evaluation based upon the criticism that its questions do not rely on individual preferences (HAS, 2011). However, the SF-6D, developed by Brazier *and al.* (Brazier and al, 1998) enables QALYs to be obtained from the SF-36 for use in cost-utility analysis. His algorithm was considered as having more rigorous methodological and theoretical bases, and better robustness of results (Pickard and al, 2005). Although the SF-6D has not been validated in France (HAS, 2011), in the absence of an alternative, we used this scale to estimate QALYs. From utility scores generated, the number of QALYs was calculated by multiplying the length spent in health states) by preference scores associated with these conditions (HAS, 2011). QALYs gained by the intervention were calculated by adopting the area-under-the-curve method and assuming that patients return after 12 months (at their level in the inclusion) (Richardson G and Manca, 2004). For each group, the mean value was calculated and the average utility of the vertebroplasty group was subtracted from the average utility group TLSO. The formula used was as follows (Drummond and al, 2005):

$$QALY = \frac{1}{12} \times (\alpha \times (SF6D_{baseline} + SF6D_{1month}) \times 1 + \alpha_1 \times (SF6D_{1month} + SF6D_{3month}) \times 2 + \alpha_2 \times (SF6D_{3month} + SF6D_{6month}) \times 3 + \alpha_3 \times (SF6D_{6month} + SF6D_{baseline}) \times 6 - [(\beta \times (SF6D_{baseline} + SF6D_{1month}) \times 1 + \beta_1 \times (SF6D_{1month} + SF6D_{3month}) \times 2 + \beta_2 \times (SF6D_{3month} + SF6D_{6month}) \times 3 + \beta_3 \times (SF6D_{6month} + SF6D_{baseline}) \times 6]$$

where α, α_1, α_2, α_3/ β, β_1, β_2, and β_3 correspond to the length spent in health states at baseline, 1, 3 and 6 months for vertebroplasty/TLSO group.

Imbalance in baseline utility must be taken into account for the estimation of mean differential QALY by multiple regression methods (Manca and al, 2005). A regression using ordinary least square was used (Glick and al, 2007), controlling by sex, age, degree of kyphotic angle and the SF-6D at baseline. Selection of variables was made from successive “step by step” iterations, removing variables not significantly associated with QALYs. QALYs derived from this model were used in our main analysis.

2.4. Cost estimation

Data was collected between October 2013 and March 2014. The costing analysis was done following the recommendation of the French Health Authority which recommends systematically adopting a societal perspective (HAS, 2011; CES, 2003). Direct costs related to care and indirect costs associated with cessation of work are considered. However, costs were disaggregated in order to take into account the recommendations of other international institutions such as the National Health Service in England, Statutory Health Insurance in Germany and Medicare in the United States (Sullivan and al, 2009; Fricke and Dauben, 2009; NICE, 2013), which recommend adding other perspectives.

We then added the health insurance, and also the patient perspectives. The cost of production was first estimated: the manufacturing cost of the brace in the TSLO arm and the cost of vertebroplasty procedure in the second arm. The cost associated with vertebroplasty includes the costs of the injected material, the utilization of the neuroradiology room, imaging explorations and biology examinations, anesthesia, consultations and acts performed during follow-up. For each technique, the costs of hospitalization, imaging and ambulatory care were included.

Price data for the cost of brace and the cost of injected material are from the imaging center of the hospital of Clermont-Ferrand, for which prices are presented inclusive of VAT. The cost of imaging acts, anesthesia and capital facilities were evaluated based on their Relative Cost Index (ICR in French). This index expresses the level of mobilization of human and material resources, directly necessary to fulfill each act (CES, 2003). The cost of an ICR unit of each component was multiplied by the number of necessary ICR corresponding to each patient's act.

The cost of biological tests was calculated from the agreed Social Security fee. The cost of single use materials and consumables for vertebroplasty was assessed from a standard list, prepared by the nursing staff. The cost of hospital stays was evaluated by the French national hospital administrative database, *Programme de Médicalisation des Systèmes d'Information* (PMSI) from cost per the French Diagnosis-Related Group (DRG), which uses 2011 data from the French National Scale of Costs database. The French National Scale of Costs allows the calculation of complete cost per stay and a full cost by DRG. The French DRG is a composite index of diseases, to the extent that a number of pathologies are related to a DRG and that the same pathology is found in several DRG (CES, 2003). For these reasons, we have adopted the "*DRG modified*" approach ("DRG *aménagé*") (CES, 2003) and replaced the variable medical costs related to anesthesia, imaging, interventional imaging, laboratory tests, consumables, medical devices by observed cost directly attributable to the implementation of oth technical. For fixed costs, we used data from the French National Scale of Costs.

Daily hospital charges and the cost of follow-up (imaging, physiotherapy and nursing home consultations) were evaluated from Social Security official tariffs. The cost of a hospital day was multiplied by the number of days of hospitalizations for each patient. Similarly, the cost of a physiotherapy session, nursing consultation and imaging was multiplied by the number of sessions performed for each patient.

Indirect costs related to the potential loss of production, were evaluated from the average value of a daily allowance paid by health insurance under cessation of work (Cour des Comptes, 2012), those related to production losses from the commercial sphere were estimated from the daily average wage income of the French population (INSEE, 2014).

The variation in costs and outcomes was undertaken to see if our results are specific to France. All costs were estimated in €, and a discount rate of 4% was applied in accordance with the recommendations of the HAS (HAS, 2011).

2.5. Cost-effectiveness analysis

The mean difference between the two strategies for the total costs and for each cost component was tested with the Student's *t*-test. A nonparametric bootstrap (2,000 replicates) was used to estimate confidence intervals (Glick and al, 2007). To counteract the imbalances between the groups, we adopted a generalized linear model (GLM) to estimate the incremental cost (Glick and al, 2007; Ramsey and al, 2005; Blough and al, 1999; Butin and al, 2004; Manning and Mullahy, 2001), controlling for age, sex, history of existence of vertebral fractures, cement leakage and severity of fracture from the patient's perspective; and the average degree of kyphotic angle, sex, and the SF-6D at baseline for the health insurance and society perspectives. Independent variables have been selected from successive "step by step" iterations.

Family function was selected with a Parks Modified-test and goodness of fit test was performed (Glick and al, 2007). These tests were the Pearson correlation test and the Hosmer & Lemeshow test Modified (for systematic bias in fit on raw scale) and the Pregibon link test (for linearity of response on scale of estimation). Costs derived from these models were used in our cost-effectiveness analysis. Poisson distribution with a log link were the best fit for the perspective of the health insurance and the patient, and the gamma distribution with a log link were the best fit for the perspective of society. The incremental cost-effectiveness ratios (ICERs) were calculated as follows:

$$ICER = \frac{\text{Incremental difference in total costs}}{\text{Incremental difference in QALYs saved}}$$

The uncertainty was estimated using a nonparametric bootstrap (O'Brien and Briggs, 2002) generated by the "recycled predictions' (Glick and al, 2007). Common in cost-effectiveness analyses for balanced data between different groups, this method consists of encoding each patient as if it were part of the control group and predicting the results for each individual, then encoding each patient as if they were part of the treatment group and predicting the results for each individual.

Cost-effectiveness acceptability curves were constructed (O'Brien and Briggs, 2002; Black, 1990; Fenwick and Byford, 2005). The cost-effectiveness acceptability curve shows the probability that the new intervention is cost-effective compared to the former based on the willingness to pay of the community (O'Brien and Briggs, 2002). In France, there is no threshold/QALY gained for judging whether or not to adopt a new technology. In England, the threshold of €30,000 (£20,000) is generally adopted (Weinstein, 2008). In Germany, there is also no official threshold, but some health economists use a threshold of €50,000/QALY (Willich and al, 2006). These two thresholds are therefore used in our analysis. The cost/QALY represents the willingness to pay. Data analyses were performed with the STATA/SE12 (StataCorp LP) software.

2.6. SENSITIVITY ANALYSIS

To assess the robustness of the results, sensitivity analyses were conducted. In the first sensitivity analysis, we varied the discount rate to 0% (26); 10% (Coyle and Tolley, 1992) but also 2.5% to take into account discussions inside the French Health Authority (HAS) about a potential revision of discount rate recommendation and also those of other international institutions. The proper discount rate is controversial. Often 3%, 3.5% or 5 % is suggested in international clinical practice guidelines (both for costs and outcomes) [Fricke and Dauben, 2009; NICE, 2013; Husereau and al, 2013). Then, we evaluated the effect of different model specifications for the cost estimate. Specifically, we used estimates of the difference in costs arising from use of ordinary least squares (OLS) regression in order to compare results derived by use of a GLM.

3. RESULTS

3.1 STUDY POPULATION

99 patients were included in the analysis (vertebroplasty: 51; TLSO: 48). The mean age and the distribution of women was 44.5 years and 41.2% in the vertebroplasty group and 45.3 years and 41.2% in TLSO group. Demographic and clinical characteristics are identical between the two groups. In 74% of patients, one vertebra only was fractured.

3.2 ANALYSIS OF COSTS

Table 1 shows that due to a higher cost of the intervention (which included the occupation of the room and anesthesia); the average hospital cost is greater for the vertebroplasty group (€3,489) than for the TLSO group (€502) (bootstrap 95% CI €2,813 to €3,158). The average cost of consumables (single-use equipment, cement for vertebroplasty group and brace for TLSO group) was 932€ for the TLSO group and € 525 for the vertebroplasty group (bootstrap 95% CI €-420 to €-361). However, radiology and laboratory exams are not statistically significant between the two groups (bootstrap 95% CI €-35 to €2).

From the perspective of health insurance, vertebroplasty is associated with lower cost of patient follow-up (consultations physiotherapy and nursing home visits) than the TLSO group (€311 versus €606, bootstrap 95% CI €-450 to €-115). However, vertebroplasty is associated with a higher cost of imaging act (€134) than the TLSO group (€103.9) (bootstrap 95% CI €18 to €44). The average cost/patient was insignificantly different between the two arms (bootstrap 95% CI €-1,048 to €1,207).

In contrast, the indirect costs (severance daily paid under cessation of work) was not statistically significant between the two groups (€1,652 versus €1,348, bootstrap 95% CI €-1,047 to €407).

When we consider the patient perspective, the cost of hospital fees was significantly lower (€79.9) for the vertebroplasty group than the TLSO group (€1,067), (bootstrap 95% CI €-1,117 to €-851). The main reason is that vertebroplasty is a free act and therefore fully covered by health insurance, unlike the brace, which is not fully covered by health insurance (80%). The technique of vertebroplasty is associated with a lower cost of follow-up (physiotherapy and nursing) (€402.5 versus €207.8, bootstrap 95% CI €-300 to €-77). Indirect costs were not statistically significant between the two groups (€3,788 versus €3,090, bootstrap 95% CI €-2,401, €934). From the society perspective, the average cost/patient was not significantly different between the two groups (€13,072 versus €14,290, bootstrap 95% CI €-1367, €3,836).

Table1: Estimated mean (SE) cost for patient (univariate analysis), SF-6D utility scores and QALYs

Cost component	TLSO (N=48) (SD)	Vertebroplasty (N=51) (SD)	Difference (95% CI†)	*p for différence*
Occupancy room (1)	426.3 (0)	1,131.4 (235.8)	703.9 (644; 1,935)	<0.001
Anesthesia (2)	0 (0)	1,832.6 (382)	1,831.6 (1,740; 1,941)	<0.001
Exam act (3)	145 (54.3)	118.3 (36.7)	-17.6 (-35; 2)	0.07
Consumable (4)	932.5 (20.7)	524.8 (11.3)	-400.3 (-420; -361)	<0.001
GHMs net of anesthesia, imaging, interventional imaging, laboratory tests, consumables and medical devices (5)	1,485.6 (76)	1,589.2 (79.8)	51.8 (48,3 ; 55,3)	0.5
Health insurance medical device reimbursement (6)	2,540.3 (144.9)	1,705.7 (581.9)	-833.5 (-966 ; -642)	<0.001
Reimbursement of hospitalization by health insurance‡ (7)	4,905.2 (1,899.2)	5,571.7 (2,431.4)	641.7 (-181; 1,945)	0.1
Imaging act (8)	103.9 (38,1)	134.2 (28.5)	30.5 (18; 44)	<0.001
Follow-up consultation (9)	605.5 (423,6)	310.7 (429.4)	-292.3 (-450; -115)	0.002
Daily allowance paid (10)	1,652.1 (2,080)	1,348.1 (1,704)	-318.9 (-1,047; 407)	0.37
Health insurance cost (11) = (1)+(2)+(3)+(4)+ (5) – (6)+(7)+(8)+(9)+(10)	**7,266.7 (3,040)**	**7,364.7 (2,781)**	**75.3 (-1,048; 1,207)**	**0.9**
Lump sum at hospital (Hospital charges) (12)	1,067.5 (477.6)	79.9 (28.4)	985.8 (-1,117; -851)	<0.001
Imaging act (13)	45.4 (15.1)	57.6 (12.2)	11.9 (7; 17)	<0.001
Follow-up consultation (14	402.5 (282.4)	207.8 (286.2)	-194.9 (-300; -77)	0.002
Production loss of market sphere (15)	3,788 (4,770)	3,090.1 (3,908)	-731.2 (-2,401; 934)	0.4
Patient cost (16)= (12)+(13)+(14)+(15)	**5,303.4 (4,875.3)**	**3,435.4 (3,884.8)**	**-1,900.7 (-3,563; -218)**	**0.02**
Society cost (18)=(11)+(12)+(17)	**13,071.9 (7,606)**	**14,289.5 (5,851.1)**	**1,165 (-1,367; 3,836)**	**0.36**
SF-6D				
Baseline (SD)	0.670 (.158)	0.689 (0.13)		
One month (SD)	0.527 (0.08)	0.578 (0.09)		
Three month (SD)	0.605 (0.01)	0.628 (0.11)		
Six month (SD)	0.649 (0.11)	0.695 (0.12)		
QALY				
Univariate analysis	**0,445 (0.008)**	**0,458 (0.01)**	**0,013**	**-0.0133 ; 0.0407**
Multivariate analysis	**0.440 (0.009)**	**0.455 (0.01)**	**0.015**	**-0.0105 ; 0.0442**

†CIs estimated using 2,000 non-parametric bootstrapping replicates. TLSO: Thoracolumbosacral orthosis

3.3 QALYs

Table 1 shows the SF-6D scores for each arm at baseline and at one, three and six months. The average QALYs (SD) were estimated at 0.440 (SD=0.009) for the TLSO group and 0.455 QALYs (SD=0.01) for the vertebroplasty group. The difference in QALYs during the six months of the study was not statistically significant between the two groups (bootstrap 95% CI -0.0105 to 0.0442). We find similar results for the univariate analysis (bootstrap 95% CI 0.0133, 0.0407).

3.4 Incremental Cost-Effectiveness Ratio

The ICER were €-12,200 (-183/0,015) for the health insurance perspective, €159,200 for the patient perspective (2,388/0,015) and €119,466 (1,792/0,015) for the society perspective (Table 2).

Tableau 2: Incremental cost, incremental QALY and ICER vertebroplasty versus TLSO, main analysis (4% of discount rate)

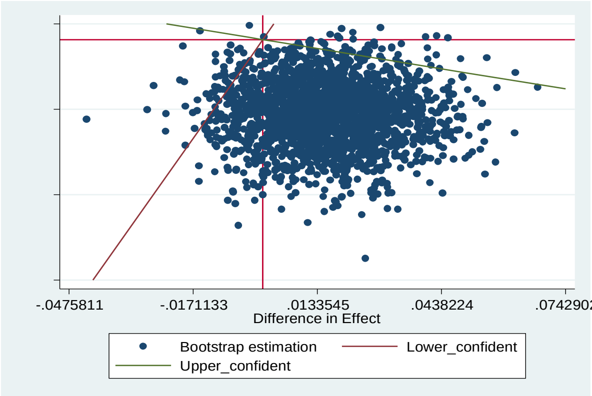
Perspective	Incremental cost (€, 95 % CI†)	Incrémental Effect (QALY, 95% CI†)	ICER	Lower confident limit	Upper confident limit	% of acceptability	
						€20,000	€ 50,000
Health insurance	-183 (-1,549; 1,165	0.015 (-0.01;0,04)	-12,200	Undefined		72.5%	81.3%
Patient	-2,388 (4,456; -376	0.015 (-0.01;0,04)	-159,200	181,049	-20,829	99.8%	99.6%
Society	1,792 (-1,890; 5,542	0.015 (-0.01;0,04)	128,142	Undefined		18.3%	28.2%

†CIs estimated using 2,000 non-parametric bootstrapping replicates; ICER: Incremental Cost-Effectiveness Ratio; TLSO: Thoracolumbosacral orthosis

Figures 1 show the results of the bootstrap procedure plotted on a cost-effectiveness plane. These figures plot the differences in costs and differences in QALYs observed in the 2000 bootstrap replicates from which acceptability curves were plotted (Figures 2). From a health insurance perspective, the dispersions are such that no 95% CI for the ratio could be identified, which means that we can be 95% confident that the two strategies differ from each other.

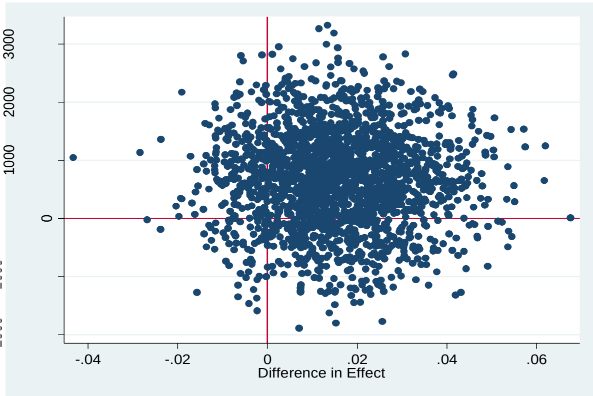
Figure 1 : Cost-effectiveness planes for patient, health insurance and societal perspective

<u>Patient perspective</u>



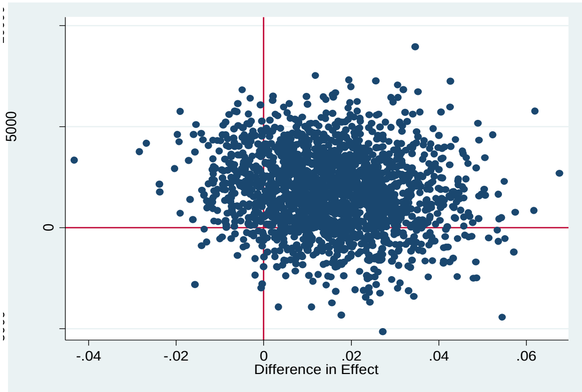
Bootstrap evaluation of incremental costs and QALYS between vertebroplasty group and TLSO group for patient perspective. perspective. ICER = €159,200 ; 95% CI : undefined

<u>Health insurance perspective</u>



Bootstrap evaluation of incremental costs and QALY between vertebroplasty group and TLSO group for health insurance ICER = €199,066 €; 95% CI: 181,049; -20,829.

<u>Societal perspective</u>

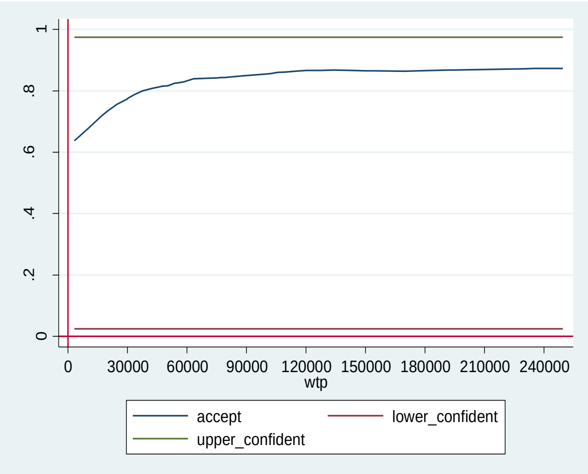


Bootstrap evaluation of incremental costs and QALYS between vertebroplasty group and TLSO group for society perspective. ICER = €119,466 ; 95% CI : undefined

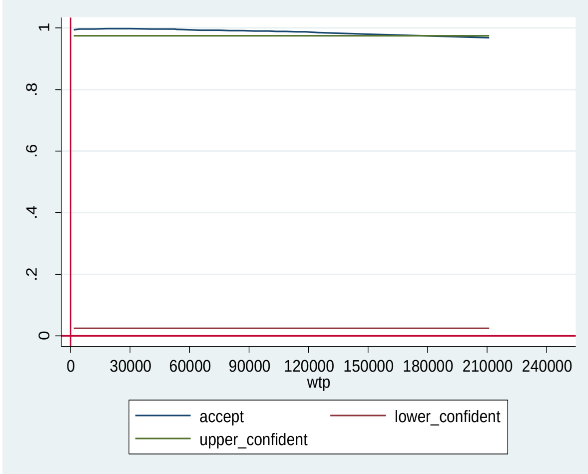
Acceptability curves (Figures 2) provide a more complete understanding of the degree of confidence that we can have in the comparison between strategies. From the patient's perspective, the acceptability curve shows that for a willingness to pay of €20,000 there was a 99.8% chance that the vertebroplasty is more cost-effective than the TLSO and a 99.6% (of) chance that the vertebroplasty is more cost-effective than the TLSO for willingness to pay of €50,000. However, from a health insurance and societal perspective, the acceptability curve does not cross the acceptability of 2.5% and 97.5% levels, we cannot conclude the superiority of one or other technique.

Figure 2: Cost-effectiveness acceptability curves for health insurance, patient and societal perspectives

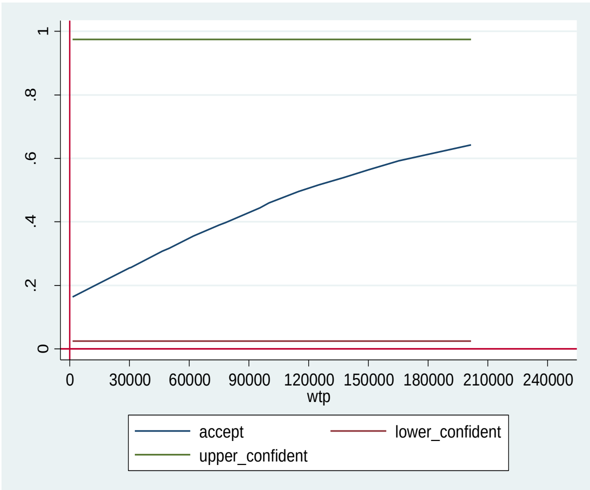
Health insurance perspective



Patient perspective



Societal perspective



The results of our sensitivity analyses are shown in Annex (Table A1 to A3). Modifications in the models' specification do not change our results, whatever the discount rate. Specifically, from the perspective of society, the 95% CI were undefined for all models, and acceptability curves remain similar.

4. DISCUSSION

Our objective was to assess the cost-utility of vertebroplasty in the context of post-traumatic vertebral fractures. This is the first study analysing the cost-utility of this technique versus TLSO in the context of post-traumatic vertebral fractures. Literature about this technique focuses more on the osteoporotic fractures (Voormolen and al, 2007; Rousing and al, 2009; Diamond and al, 2006; Diamond and al, 2003; Ploeg and al, 2006; Masala and al, 2009; Klazen and al, 2010) and many of them analyze the vertebroplasty versus kyphoplasty method (Svedbom and al, 2013; Fritzell and al, 2011).

Following the French Health Authority recommendations, which recommend a societal perspective; we have deliberately chosen to disaggregate perspectives (health insurance, patients, and society) to separate their respective costs and to include recommendations from other institutions for economic evaluations: health system or payer perspective (National Health Service in England, Statutory Health Insurance in Germany and Medicare in the United States).

Vertebroplasty technique requires higher intervention cost (€2,964) than TLSO (€426). That makes sense insofar as vertebroplasty requires expensive equipment and consumables, unlike the TLSO, for which the main expense is the brace itself. However, vertebroplasty was less costly in radiology exams at baseline, where a significant, but small, difference of €17 is observed. Moreover, the costs of follow-up were also lower for vertebroplasty (€517.9) than for TLSO (€1,009.4), where a difference of €487 is observed. However, although the duration of work cessation was more important for the TLSO arm (116 days) than for vertebroplasty (82 days), no significant differences in indirect costs were observed.

The idea of using threshold values in decision-making encountered some criticism, such as, among others, the risk of uncontrolled growth of health care spending. However, the thresholds represent society's willingness to pay for health care, and for that, this (decision) rule is considered more appropriate for policymakers (Eichler and al, 2004). In France, no threshold value is given by the competent authorities, so we took two different thresholds: €20,000 and €50,000.

Our analysis shows mixed results depending on the chosen perspective. For the hospital perspective, we concluded in favor of TLSO; conversely, from the patient's point of view, vertebroplasty is the dominant strategy. This is explained by the fact that the patient needs a longer period of bed rest with TLSO than for vertebroplasty which, induces faster recovery and a lower cost of follow-up. As there is a gain for the patient, an argument can be provided that health insurance may increase the budgetary allocation. On the other hand, an argument can be given that complementary health insurance may assume the cost for the patient to the extent that the cost of vertebroplasty is less than the TLSO.

In contrast, no difference in the relative cost-effectiveness of the vertebroplasty compared with the TLSO appears from a health insurance and society perspective. For these last two perspectives, the differences in costs and the differences in QALYs between the two groups were not significant. However, despite these not significant results, we nevertheless performed an economic analysis, insofar as it is possible to have a greater confidence in the joint outcome of costs and QALYs than about either of the outcomes individually (Glick and al, 2001). For these two perspectives, we are therefore unable to determine whether vertebroplasty is more effective than the TLSO.
Sensitivity analysis does not change the results. The disaggregated results allow us to choose the desired perspective, depending on the institution (societal for France, health system or payer perspective for England, Germany or the United States). The first drawback of our study is the exclusion of costs (presenteeism costs, patient’s family costs...) although several studies show a significant impact on the results (Pauly, 2008; Collins and al, 2005; Burton, 2005) and which would have allowed us to have a more complete picture of the cost analysis. This non-inclusion can be explained by the fact that the clinical study had previously been designed without economic evaluation, the choice of integrating a medico-economic component has come at the end of the clinical study. We have thus not been able to establish all the elements necessary for a complete analysis. Similarly, the study of follow-up costs does only limit to hospital prescriptions, omitting any eventual prescriptions made by the family doctors, but also supplementary cessation of work. In the context of cessation of work, we hypothesized that patients returned to full-time employment, or it is possible that some have benefited from part-time work arrangements. The second drawback concerns the QALYs calculation. We used the Brazier *al.* algorithm of converting data from SF-36. Despite its rigorous theoretical and methodological bases (Pickard and al, 2005), the weighting function for assigning a weight to each of these states was calculated from the United Kingdom population, which does not necessarily reflect the preferences of the French population. The QALYs via VAS could be calculated, however, many health economists considering that VAS are not considered as utilities insofar as it does not require explicit choice and has scales undesirable properties (Nord, 1991). The third drawback is the fact that the trial was not blind, patients knew which treatment they were receiving. Knowledge of treatment assignment probably influenced patients' responses during evaluations. Finally, the six month follow-up period was too short. A much longer evaluation of these two strategies especially in terms of costs (re-hospitalization, sick leave...) should be considered.

In conclusion, our analysis shows mixed results depending on the chosen perspective. The choice of perspective will depend on what the government wants to give preference to, namely the financial resources of patients, to the detriment of the budgetary impact, or consider that budgetary impact is most important. In France, where the excess for the patient is low (approximatively €290) the government's position will not favor this approach. In constrast, in the United States, health-related costs are very high and the excess for the patient is important, the government's position could be different due to excessive coverage.

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Annex

Tableau A1: Incremental cost, incremental QALY and ICER vertebroplasty versus TLSO, univariate analysis

Perspective	Incremental cost (€, 95 % CI†)	Incrémental Effect (QALY, 95% CI†)	ICER	Lower confident limit	Upper confident limit	% of acceptability	
						€20,000	€ 50,000
Discount rate 0%							
Health insurance	-94.2 (-1,087; 1,333)	0.014 (-0.01;0.06)	-6,729	Undefined		61%	72.7%
Patient	-2,008 (-3,764; -230)	0.014 (-0.01;0.06)	-143,428	93,652	-13,920	99.3%	99.2%
Society	1,138 (-1,544; 3,971)	0.014 (-0.01;0.06)	81,286	Undefined		26.9%	39.4%
Discount rate 2.5%							
Health insurance	-92.5 (-1,042 ; 1,282)	0.016 (-0.013 ; 0.05)	-5,781	Undefined		61.2%	73.2%
Patient	-1,339.8 (3,636; -222)	0.016 (-0.013 ; 0.05)	-83,687	93,652	-13,920	99.3 %	99.2%
Society		0.016 (-0.013 ; 0.05)	72,625	Undefined		24.4%	37.2%
Discount rate 4%							
Health insurance	-75.3 (-1,048; 1,207)	0.016 (-0.013 ; 0.04)	-4,706	Undefined		61.3%	73.2%
Patient	-1,901 (-3,563; -218)	0.016 (-0.013 ; 0.04)	-118,812	93,652	-13,920	99.3%	99.2%
Society	1,165 (-1,367; 3,836)	0.016 (-0.013 ; 0.04)	72,812	Undefined		24.4%	37.2%
Discount rate 10%							
Health insurance	-65.4 (-978; 1,146)	0.016 (-0.009; 0.04)	-4,087	Undefined		61.9%	73.3%
Patient	-1,757 (-3,294; -133)	0.016 (-0.009; 0.04)	-109,812	93,652	-13,920	99.3%	99.2%
Society	1,265 (-1,067; 3,713)	0.016 (-0.009; 0.04)	79,072	Undefined		21.3%	32.9%

†CIs estimated using 2,000 non-parametric bootstrapping replicates.
ICER: Incremental Cost-Effectiveness Ratio
TLSO: Thoracolumbosacral orthosis

Tableau A2: Incremental cost, incremental QALY and ICER vertebroplasty versus TLSO, multivariate analysis GLM

Perspective	Incremental cost (€, 95 % CI†)	Incrémental Effect (QALY, 95% CI†)	ICER	Lower confident limit	Upper confident limit	% of acceptability	
						€20,000	€ 50,000
Discount rate 0%							
Health insurance	-185 (-1,616; 1,236	0.016 (-0.01;0.06)	-11,562		Undefined	81.3%	81,3%
Patient	-2,461 (-4,708;398)	0.016 (-0.01;0.06)	-153,813	181,050	-20,829	99.8%	99.6%
Society	1,787 (-2,094; 5,739)	0.016 (-0.01;0.06)	111,688		Undefined	23.6%	27.1%
Discount rate 2.5%							
Health insurance	-179 (-1,542; 1,075)	0.014 (-0.009;0.04)	-11,187		Undefined	72.8%	81.2%
Patient	-2,378 (-4,119; -348)	0.014 (-0.009;0.04)	-148,625	181,049	-20,829	99.8%	99.6%
Society	1,792 (-1,837; 5,496)	0.014 (-0.009;0.04)	112,000		Undefined	22.4%	32.3%
Discount rate 4%							
Health insurance	-176 (-1,573;1,214)	0.016 (-0.01;0.06)	-11,000		Undefined	73.1%	81,7%
Patient	-3,098 (-4,708;398)	0.016 (-0.01;0.06)	-193,625	181,050	-20,829	99.8%	99.5%
Society	1,387 (-2,094; 5,739)	0.016 (-0.01;0.06)	86,687		Undefined	29%	39.5%
Discount rate 10%							
Health insurance	-175 (-1,417; 1,056)	0.014 (-0.009;0.04)	-12,857		Undefined	72.5%	81.3%
Patient	-2,032 (-3,788; -308)	0.014 (-0.009;0.04)	-173,293	181,049	-20,829	99.8%	99.6%
Society	1,407 (-2,112; 4,841)	0.014 (-0.009;0.04)	100,500		Undefined	24.1%	33.1%

†CIs estimated using 2,000 non-parametric bootstrapping replicates

ICER : Incremental Cost-Effectiveness Ratio

TLSO: Thoracolumbosacral orthosis

Tableau A3: Incremental cost, incremental QALY and ICER vertebroplasty versus TLSO, multivariate analysis OLS

Perspective	Incremental cost (€, 95 % CI†)	Incremental effect (QALY, 95 % CI†)	ICER	Lower confident limit	Upper confident limit	% d'acceptabilité	
						€20,000	€50,000
Discount rate 0%							
Health insurance	-176 (-1,573 ; 1,114)	0.016 (-0.01;0.06)	-11,000		Undefined	73.1%	81.7%
Patient	-3098 (-2,882; -331)	0.016 (-0.01;0.06)	175,375	173,293	-18,100	99.8%	99.5%
Society	1,387 (-2,365 ; 5,070)	0.016 (-0.01;0.06)	86,688		Undefined	29%	39.5%
Discount rate 2.5%							
Health insurance	-172 (1,517 ; 1,166)	0.014 (-0.009;0.04)	10,731		Undefined	73.3%	81,8%
Patient	-2,243 (-4,181; -340)	0.014 (-0.009;0.04)	-140,187	173,293	-18,100	99.8%	99.5%
Society	1,401 (-2,206; 4,927)	0.014 (-0.009;0.04)	87,562		Undefined	28%	38.1%
Discount rate 4%							
Health insurance	-175.5 (-1,505 ; 1,147)	0.016 (-0.01;0.06)	-12,536		Undefined	73.5%	82%
Patient	-2,198 (-4,097; -333)	0.016 (-0.01;0.06)	-157,000	173,293	-18,100	99.8%	99.5%
Society	1,403 (-2,161 ; 4,882)	0.016 (-0.01;0.06)	100,214	Undefined	27.6%	37.4%	33.9%
Discount rate 10%							
Health insurance	-174.7 (-1,417 ; 1,056)	0.014 (-0.009;0.04)	-12,479		Undefined	73.8%	82.1%
Patient	-2,032 (-3,788; 308)	0.014 (-0.009;0.04)	-145,142	173,293	-18,100	99.8%	99.5%
Society	1,407 (-2,112 ; 4,841)	0.014 (-0.009;0.04)	106,214		Undefined	24.1%	33.9%

†CIs estimated using 2,000 non-parametric bootstrapping replicates

ICER : Incremental Cost-Effectiveness Ratio

TLSO: Thoracolumbosacral orthosis