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The Incremental Cost Efectiveness of In-Patient Versus Out-Patient Rehabilitation after Total Hip Arthroplasty – Results of a Pilot Investigation

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Abstract
Purpose: Total hip arthroplasty (THA) is an established and cost effective procedure in the treatment of severe arthritis of the hip. However, bearing recent demographic changes in mind, the increasing demand for total hip arthroplasty during the next decades catalyzes health economic re-consideration of the overall health care process of initial surgery and subsequent rehabilitation. One point for discussion is due to postoperative rehabilitation, since direct costs of the latter crucially depend on whether in-patient (indoor) or out-patient (outdoor) rehabilitation is recommended. Whereas out-patient rehabilitation is obviously more cost efficient from a health insurer's perspective than its indoor alternative, it is open for discussion, whether the alternatives' clinical benefit profiles from a patient's perspective are of comparable order. Therefore this pilot investigation was implemented to assess the clinical benefit and cost effectiveness of in-patient versus out-patient rehabilitation after THA.
Methods: A total of 28 patients (16 females) were enrolled in this retrospective matched pairs cohort study. All patients underwent THA in 2006 and were then assigned to either in-patient (n = 14) or out-patient (n = 14) postoperative rehabilitation at cooperating departments. The in-patient and out-patient samples were recruited from an epidemiological register trial on THA outcome, and matched 1 : 1 according to gender, age at surgery, working and family state. Preoperative assessment of (algo-) function as well as clinical outcome six months after surgery were based on the WOMAC questionnaire. Primary clinical endpoint of this investigation was the intraindividual increase in the WOMAC score [%], which was transformed into a utility scale ranging from 0 – 100% (optimum self-rating) and then into the number of gained quality adjusted life years [QALY]. Primary economic endpoint were the total direct costs [€] for the overall treatment including surgery and rehabilitation from the health care insurer's perspective; costs for surgery and stationary care were calculated by means of German DRG rates, costs for postoperative rehabilitation by means of daily rates for indoor and outdoor care and the individual duration of rehabilitation. Based on these primary endpoints, the marginal cost effectiveness ratio [€/QALY] was estimated for the indoor and the outdoor based health care process, respectively.
Results: The matched pairs' median age difference was 2 years, their median difference in body mass index 0.8 kg/m². Outdoor patients reported a median WOMAC score of 38% before and 87% after surgery, indoor patients of 41% and 88%. Matched pair evaluation revealed a median difference of 5% (interquartile range -18% – 26%) between the matched pair partners' respective WOMAC increases indicating gradual superiority of in-patient rehabilitation (sign test p = 0.719). This WOMAC difference corresponded to a median clinical benefit difference of 0.77 QALYs (interquartile range -2.13 – 3.18 QALYs) between indoor and outdoor patients. The total direct costs for surgery, postoperative care and rehabilitation were calculated 8706 € in median for out-patient and 9126 € in median for in-patient rehabilitation, their respective median matched pair difference was 420 € (198 – 475 €, p = 0.013). In summary, the marginal cost effectiveness ratios showed a matched pair difference of -841 € / QALY (sign test p = 0.791). The latter demonstrated – not significantly – smaller marginal costs of indoor rehabilitation.
Conclusion: In this matched pilot investigation the overall health care process involving in-patient rehabilitation after total hip arthroplasty did not demonstrate a significantly superior cost effectiveness when compared to its out-patient alternative from a health care insurer's perspective. This observation is complemented by a rather small difference in clinical benefit. However, prospective investigations, which should randomize the rehabilitation alternatives onto appropriate patients, are necessary to confirm the above pilot results.

Key words: Total Hip Arthroplasty (THA), in-patient rehabilitation, out-patient rehabilitation, clinical benefit, incremental cost effectiveness

Introduction

Recent demographic changes in Western Europe imply an increasing demand for health care procedures in the elderly and thereby increasing ressource allocation

by health care insurers. Orthopedic surgery is pretty concerned with the treatment of the older patient [5], since the demand for total joint replacement is catalyzed by both demographic changes and availability of effective and safe treatment procedures. In particular, total hip arthroplasty (THA) presents a treatment offer to the older patient, who often suffers from a severe loss in quality of life due to arthritis of the hip, but also from prognostically relevant comorbidity [24]. Therefore a direct cost assessment of THA based on diagnose related groups (DRGs) will result in a rather cost-intensive reimbursement for health care insurers. Accordingly, the German DRG rate for unilateral THA amounts to 7000 € plus the direct costs for postoperative rehabilitation, which at least amount to additional 2000 €. On the other hand, THA has been proven to be effective from the patients' perspective concerning regain of both function and quality of life [2, 14].

However, bearing recent demographic changes in mind, the increasing demand for total hip arthroplasty during the next decades catalyzes health economic reconsideration of the overall health care process of initial surgery and subsequent rehabilitation. One point for discussion is due to the format of postoperative rehabilitation, since direct costs of the latter crucially depend on whether in-patient (indoor) or out-patient (outdoor) rehabilitation is recommended: Whereas out-patient rehabilitation is obviously more cost efficient from a health insurer's perspective than its in-patient alternative, it is open for discussion, whether the alternatives' clinical benefit profiles from a patient's perspective are of comparable order. Whether a patient is assigned to indoor or outdoor rehabilitation after THA is often rather a surrogate of standard procedures in the underlying health care system than of individual consideration. Furthermore the patient's personal interests may interfere with the recommendation at hand: whereas the younger patient may wish to return to work as soon as possible and therefore favour outdoor rehabilitation, the older patient (who is, for example, already drawing a pension) may rather prefer the indoor care alternative. Note, however, that there remains a larger group of patients with the clinical indication for THA, which may fit the recommendation for both in-patient and out-patient rehabilitation. Both from an ethical as well as from an economical perspective, it seems legitimate to ask, which recommendation will be more cost effective in these patients.

The marginal and incremental cost effectiveness ratio concept [17, 25] provides quantitative allocation rationales in such settings: The cost effectiveness ratio relates the costs of a treatment to its benefit from a patient's perspective, mostly estimated in terms of monetary units per gained quality adjusted life year (QALY). Estimation of the treatment's effectiveness in terms of QALYs allows for a patient-related benefit interpretation as well as for comparison of its cost effectiveness estimate with the corresponding health economic charasteric of alternative treatments. In particular, the estimation of a treatment's incremental cost effectiveness enables health care insurers to evaluate its cost / benefit relation in comparison to other treatments, which already underwent this decision process for refunding.

Since clinical benefit and costs of the in-patient and out-patient rehabilitation alternatives at hand must be compared simultaneously, the incremental cost effectiveness ratio concept seems to provide an appropriate rationale from a health care insurer's perspective. Therefore this pilot investigation was implemented to assess the clinical benefit and cost effectiveness of in-patient versus out-patient rehabilitation after THA.

Material and Methods

The primary intention of this investigation was to derive an estimate for the incremental cost effectiveness of indoor versus outdoor rehabilitation after THA under stratification for putative outcome determinants such as age, gender or occupational state. Therefore a retrospective 1 : 1 matched pairs investigation with the aim of estimating the cost effectiveness of both health care procedures was implemented.

Study design and patient characteristics

This retrospective cost effectiveness investigation comprised individual data of 28 patients, who underwent unilateral THA at a University Hospital's Orthopedic Surgery department in 2006. The patients were drawn from the "Dresden hip surgery registry", which prospectively enrolls all surgical interventions performed at the department. This epidemiological trial recruites over 500 patients per year and brings them into a six months recall after surgery to estimate the initial surgery's clinical and subjective outcome. After written informed consent patients underwent an interview by means of the WOMAC questionnaire one week before surgery. The interviews were coordinated by a study nurse, who offered assistance to the interviewee if required. Furthermore the study subjects were invited for a six months recall to undergo the same interview. This study design was positively rated by the local Independent Ethics Committee by March 24th 2005.

In a first step the overall registry data base was searched for patients, who were assigned to out-patient rehabilitation after THA in 2006. A total of 17 patients were identified and their sociodemographic cofactors were recorded (age, gender, working and family state). Next the data base of all patients, who underwent in-patient rehabilitation (which is quite the standard recommendation in Germany), was searched for 1:1 matching partners according to the above sociodemographic cofactors. In summary, a total of 14 matched pairs could be identified. After matching the clinical outcome and cost data of the 28 patients was introduced into the embedded cost effectiveness evaluation.

The 28 patients (16 females) showed a median age of 56 years (range 34 – 79 years); 12 patients reported to live without a partner or family members. Two patients reported an academic degree, eight patients reported their occupational status as "working" or reported to "(intend to) restart working" after rehabilitation.

Clinical procedure

Total hip replacement surgery was performed by means of the directly lateral approach in all 14 patients. Eight patients in the outdoor rehabilitation sample versus 7 patients in the indoor rehabilitation group were implanted cementlessly (Allofit cup, CLS stem, Zimmer Ltd., Warsaw, US); four patients in both groups received a hybrid Total Hip Replacement (Allofit cup, Zimmer Ltd., Warsaw, US; cemented SP II-system, Waldemar Link GmbH, Hamburg, Germany). Two patients in the outdoor rehabilitation group versus three patients in the indoor rehabilitation group were supplied with a cemented Total Hip Replacement (SP II-system, Waldemar Link GmbH, Hamburg, Germany)

Surgery was performed under hypotensive general anesthesia. Preoperatively, all patients received one dose of an intravenous cephalosporin. Low molecular heparin (0.2-0.6 ml fraxiparine per day, weight-adapted, GlaxoSmithKline GmbH, Germany) was used for thromboprophylaxis until re-mobilization, at least for 3 weeks. 150 mg diclophenac per day was used in order to prevent the formation of heterotopic bone. Walking practice was started on the first postoperative day with full weight-bearing being allowed. All patients underwent a standardized physiotherapy program until hospital discharge at the 7th postoperative day.

Clinical benefit evaluation and model assumptions

The primary clinical endpoint of this investigation was the individual gain in quality of life as assessed by means of the WOMAC questionnaire: Before and six months after surgery patients answered the 24 WOMAC items, which were documented in terms of a five-staged ordinal scale. The 24 items were averaged and transformed into a utility scale of 0 – 100%, where the scale maximum 100% indicates the optimum well-being among each of the 24 items. The intraindividual difference post – pre of this transformed WOMAC index was then considered as a surrogate for the patients' clinical benefit achieved by THA. This surrogate was then extrapolated alongside the patients' theoretical rest life expectancy, where a Gaussian life expectancy distribution was assumed with a mean expectancy of 85 years for women and 80 years for men (both underlying standard deviations of 10 years). Based on this model assumption the individual (rest) life expectancy of a patient was simulated. The WOMAC based clinical benefit was then assumed to persist over this patient's simulated rest life period and proportionally extrapolated over time. To account for time-dependent loss in the primary clinical benefit as assessed shortly after surgery, the overall benefit estimate was discounted at an annual discounting rate of 3%. If, for example, a patient was assigned to a simulated rest life expectancy of 10 years after surgery and reported a 25% increase in terms of the WOMAC based utility scale, his individual crude benefit was estimated 10 years * 25% = 2.50 quality adjusted life years (QALYs). After discounting at the annual 3% loss rate a net THA benefit of 2.18 QALYs was then estimated for this patient.

However, since a 10 years revision rate of 5 – 10% must be assumed after THA, the above simulation of rest life expectancy also introduced a 10 years censoring for two of the patients by random selection. This model assumption allowed to also simulate the fact of loss in quality of life when a revision becomes necessary (and thereby imposes new financial investment).

Primary endpoints

The primary clinical endpoint of this investigation was the individual gain in quality of life as illustrated above [QALYs] assessed by means of the WOMAC questionnaire. The primary economic endpoint were the total direct costs [€], based on individually calculated German DRG rates for the initial THA plus the individual direct costs for the subsequent rehabilitation. The latter was deterministically modelled by extrapolation of a "daily rate" of 84 € (out-patient care) and 104 € (in-patient care) over the individually reported duration of postoperative rehabilitation. These rates were provided by the Medical Service for Statutory Health Care Insurances, Rhineland-Palatinate.

The main target parameter of the cost effectiveness evaluation was the marginal cost effectiveness ratio (MCER), which relates the direct costs as assessed by the primary economic endpoint to the associated patient benefit as assessed by the primary clinical endpoint [€/QALY]. Both cost and cost effectiveness evaluation were performed from the German compulsory health care insurer's perspective.

To briefly illustrate the estimation and interpretation of the MCER endpooint, the following numerical example will be sketched out: If, for example, an indoor patient's net clinical benefit was estimated 2.00 QALYs and the overall direct DRG costs for THA and subsequent rehabiliation were calculated 9000 €, this patient's marginal costs were estimated as MCER = 9000 € / 2.00 QALYs = 4500 € / QALY. If now this patient's matched pair partner reported a clinical benefit of 1.50 QALYs after THA and subsequent outdoor rehabilitation at a 8600 € cost level, his individual MCER was estimated 5733 € / QALY. In this matched pair setting the difference of 1233 € / QALY would obviously indicate a superior cost / benefit relation for indoor over outdoor rehabilitation.

Statistical analysis

The distributions of continuous endpoints such as the primary clinical endpoint and the MCER were described by medians and quartiles (graphically on non-parametric box plots, accordingly) to take account for possible statistical outliers. Intraindividual comparisons and matched pair comparisons were based on the description of difference distributions for continuous endpoints and on total frequencies in contingency tables for categorical endpoints. The significance evaluation of intraindividual changes and matched pair comparisons in continuous endpoints was based on pairwise sign tests. Results of these tests were summarized in terms of p-values. Due to the rather exploratory character of this pilot investigation, these p-values were not formally adjusted for multiplicity; a p-

value < 0.05 therefore indicates locally significant matched pair differences.

Before starting the investigation, a sample size calculation was performed based on the assumption of an at least 3% matched pair difference in the WOMAC increases with corresponding standard deviation of 3%. Assuming an analysis based on a paired t-test at a 5% significance level, the statistically significant detection of this difference at a minimum statistical power of 80% would require a minimum sample size of n = 10 matched pairs. To take account for the fact, that the WOMAC data may be skewed (and therefore the t-test may not be valid) and a paired sign would turn out more appropriate for analysis, recruitement of at least 13 matched pairs was recommended for the above setting.

Results

A total of 28 patients was enrolled in this pilot investigation, 14 pairs were matched 1:1 accordingly (eight female matched pairs). The median age of outdoor patients was 55 years, of indoor patients 57 years with a matched pair difference of 2 years (0 – 6 years, sign test p = 0.146); the respective median body mass indices before surgery were 26.3 and 27.6 kg/m², respectively, with a median matched pair difference of 0.8 kg/m² (-2.2 – 1.7 kg/m², sign test p = 0.791; Table 1).

Table 1. Medians and quartiles for the matched pair difference distributions of age, body mass index, pre- and postoperative WOMAC score distributions, gained numbers of quality adjusted life years QALYs], total cost rates and resulting marginal cost effectiveness ratios (MCERs) for 14 indoor and 14 outdoor rehabilitation patients after total hip arthroplasty (matched pair differences indoor – outdoor patient).

	matched pair difference (indoor – outdoor)
age [years]	2 (0 – 6)
body mass indes[kg/m²]	0.8 (-2.2 – 1.7)
WOMAC pre [%]	0 (-23 – 12)
WOMAC post [%]	1 (-20 – 25)
cost rates [€]	420 (198 – 475)
WOMAC change post – pre [%]	5 (-18 – 26)
benefit [QALYs]	0.77 (-2.13 – 3.18)
MCER [€/QALY]	– 841 (-2508 – 204)

The matched patients did neither differ (Fig. 1) in preoperative WOMAC scores (median scores of 38% versus 41% with median matched pair difference 0%, sign test p = 1.000) nor in postoperative score (median scores of 87% versus 88%, median matched pair difference 1%, sign test p = 1.000). Accordingly (Fig. 2), the samples of indoor and outdoor rehabilitation patients showed neither clinically relevant nor statistically significant differences in the WOMAC based benefit estimate: after appropriate matched pair evaluation the indoor and outdoor matched pairs showed a median difference of only 5% in their respective WOMAC score increases (interquartile range -18% – 26%; sign test for matched pair comparison p = 0.791).

After transformation into the number of gained quality adjusted life years, the respective matched pair difference between indoor and outdoor rehabilitation patients turned out 0.77 QALYs (-2.13 – 3.18 QALYs); in accordance, the matched pairs did not significantly differ in the underlying clinical benefit distribution (sign test for matched pair comparison p = 0.791).

The median overall cost rates for THA and subsequent indoor rehabilitation were estimated 9126 €, the corresponding rates for outdoor patients 8706 € (sign test p = 0.013). The matched pair evaluation of the underlying marginal costs revealed a median difference of -841 € / QALY (interquartile range -2508 – 537 € / QALY, sign test p = 0.791), indicating gradual superiority of indoor care (due to its gradually smaller marginal costs).

Female matched pairs showed a median MCER difference of -74 € / QALY, males of -1526 € / QALY, corresponding to respective benefit differences of 1.65 versus 0.60 QALYs (total sample difference 0.77 QALYs). According to the latter, female patients attested a larger superiority of indoor over outdoor rehabilitation than males, who would "buy" the smaller gain of 0.60 QALYs (indoor versus outdoor rehabilitation) at the same "price" (420 € cost increase), which would be "paid" by female study subjects for the nearly threefold clinical benefit difference of 1.65 QALYs.

Discussion

This investigation intended to quantify the clinical benefit (in terms of quality of life improvement) and the individual cost / benefit relation of total hip arthroplasty from a health insurer's perspective under particular consideration of the postoperative rehabilitation's format. Primary intention of the cost effectiveness evaluation was to derive a comparative cost effectiveness characteristic for indoor versus outdoor rehabilitation after THA and thereby to provide rationales for recent discussions on ressource allocation to Orthopedic surgery [4, 9] in Western European health care systems.

The cost effectiveness of THA has yet been widely discussed and quantified [4, 7, 8, 10, 11, 13, 15, 16, 21] in large patient samples recruited in the U.S.A. and the U.K. as well as in Scandinavia. Cost effectiveness ratios for THA were reported in a range of 1500 – 2500 € / QALY, hence its overall performance is accepted to be cost effective and comparable to that of total knee arthroplasty [18, 23]. However, a lot of this pub-

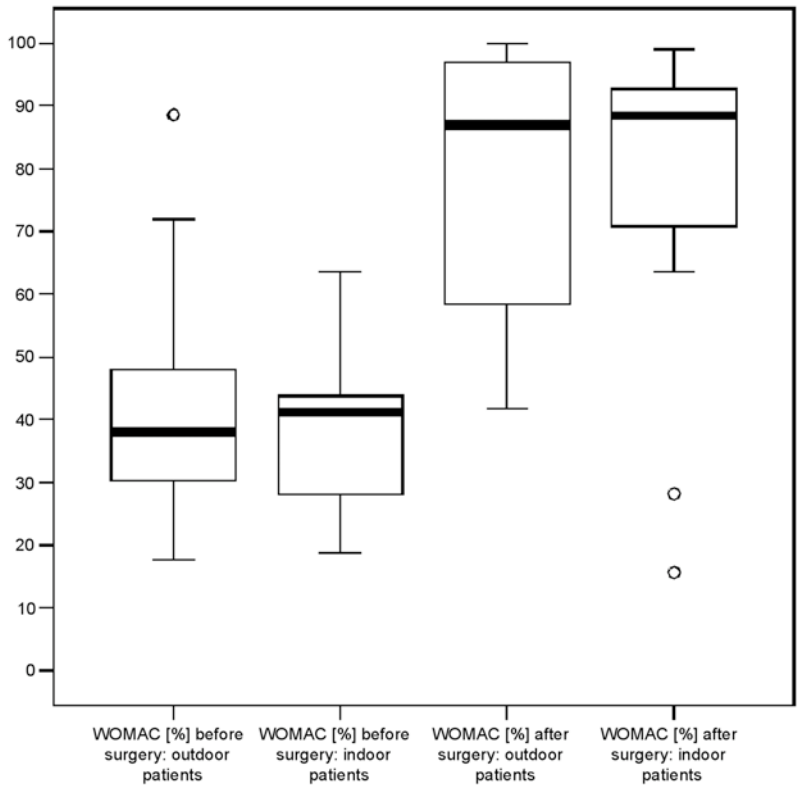

Fig. 1. box plots for the respective pre- and postoperative WOMAC score distributions of 14 indoor and 14 outdoor rehabilitation patients after total hip arthroplasty (horizontals display quartiles of the distribution, verticals minimum and maximum values, the circle indicates a statistical outlier).

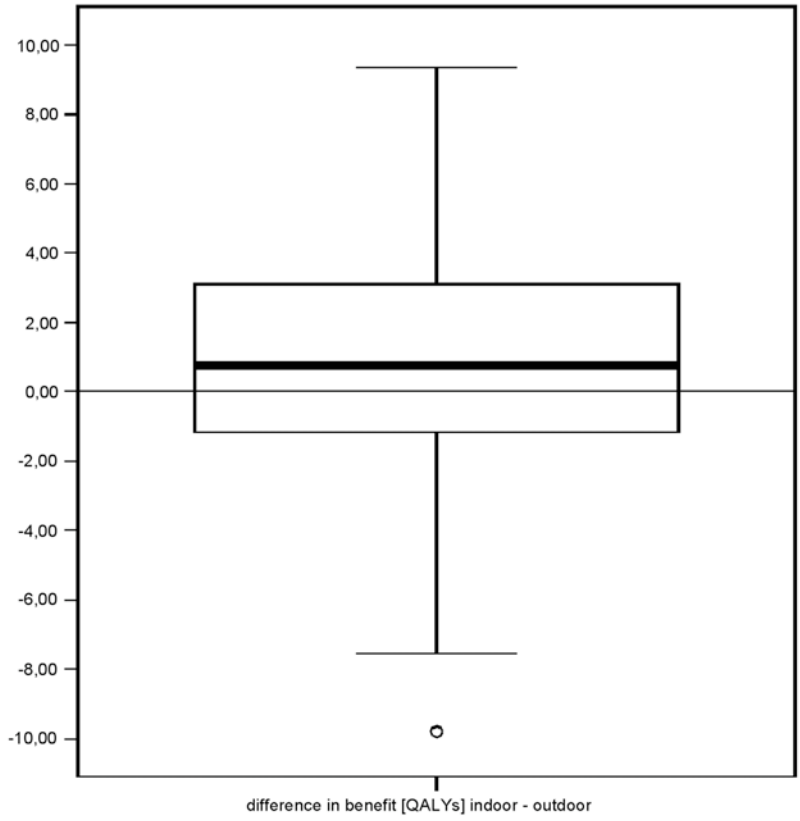

Fig. 2. box plot for the distribution of the matched pair difference in clinical benefit [QALY] evaluated for 14 indoor / outdoor rehabilitation patient pairs after total hip arthroplasty (horizontals display quartiles of the distribution, verticals minimum and maximum values, the circle indicates a statistical outlier).

lished information is – according to the actual research hypothesis at hand or due to the cost reimbursement strategies on site – rather based on the health care provider's perspective [1, 19] instead of the health care insurer's. Furthermore, most study reports rather focus on the surgical determinants of costs and cost effectiveness [1] rather than the corresponding pre- or postoperative care characteristics [20]. As a consequence, only few published data allow for quantitative consideration of the postoperative rehabilitation procedure's cost effectiveness. One reason for this lack of health economic charasteristics for rehabilitation pro-

cedures may be due to their rather moderate impact on the overall costs of the intended health care process: THA and postoperative rehabilation imply total direct costs of at least 9000 € per patient, but only about 20% of this budget is due to rehabilitation. In relation to the dominating cost profile of surgery, the economic difference between rehabilitation care offers (such as implied by indoor versus outdoor care with a cost difference of less than 20% in the German health care system) becomes merely marginal. Nevertheless, regarding the large and even dramatically increasing number of patients awaiting THA during the next decades, even this moderate saving potential earns increasing economic attention.

The above data revealed a marginal cost difference of -841 € / QALY for indoor versus outdoor postoperative care and gradual, but not significant superiority of the indoor rehabilitation concept (due to its smaller marginal costs). This observation is supported by the fact, that the underlying clinical benefit difference turned out rather small (5% matched pair difference in the WOMAC endpoint) and far beyond statistical significance. Accordingly, a matched pair difference of only 0.77 QALYs was extrapolated, since the patient samples were matched by age and thereby rest life expectancy. Note, however, that the samples did not differ concerning their clinical function ratings before surgery – confirming the fact, that this pilot investigation did not demonstrate clinically relevant advantages for one of the rehabilitation alternatives under consideration.

In summary, the lack of significant superiority in cost effectiveness found here, does not imply the necessary recommendation of in-patient rehabilitation after THA. The quite small differences in clinical benefit and cost effectiveness rather imply an open discussion on financial participation of patients, who deliberately wish to undergo in-patient rehabilitation although being elegible for out-patient care. A constructive discussion, which will have to sensitively consider identification criteria for such patients, strongly calls for further investigations at a higher sample size and design evidence level.

Methodological aspects

Because of the lacking literature the above pilot investigation was implemented both as a first primer of the possible effects between in- and out-patient care as well as a foundation for the design conception in subsequent prospective trials. Nevertheless, the results of this pilot investigation must be carefully re-considered from a methodological point of view: First note, that the WOMAC data used to assess the primary clinical benefit endpoint only presents a proxy estimate [2, 3, 22] for the patients' benefit from the overall care process: The WOMAC questionnaire rather estimates a mixture of functional and subjective outcome instead of general health-related quality of life such as measured by, for example, the EuroQol instrument [6]. On the other hand, the matched pair design in this investigation allows for 1:1 comparison of this outcome measure; it therefore eliminates this possible systematic bias in QALY estimation by its eventually homogeneous introduction into both patient samples.

A different source of bias might further have been introduced into the investigation by the duration of the recall period: note, that the recall examination was performed six months after surgery. Most patients will have finished their postoperative rehabilitation already three months before this interview. Accordingly, the benefit fraction attributable to indoor / outdoor rehabilitation will be rather difficult to quantify and rather likely be confounded by the beneficial effect of the intraportal surgical and stationary treatment. A conservative bias concerning the benefit fraction attributable to the respective rehabilitation procedures may therefore be contained in the above results. On the other hand – regarding the intended long-term benefit by THA – an earlier interview might have introduced a liberal bias into the indoor benefit estimates, because patients would still profit from the "accomodation" advantages of this care strategy, whereas outdoor patients already have to face "daily life requirements" much more frequently and intensive. Six months after surgery, both patient samples can be assumed to have re-integrated into their daily life requirements, irrespective of the previous rehabilitation procedure. As a conclusion, the six months recall interview was used for benefit estimation in the recent study design – further investigations, however, may wish to also introduce earlier interviews.

Besides the potential bias in the clinical benefit estimates, possible sources of bias in the economic endpoint evaluation must be considered as well: note, that the above cost evaluation was based on the model assumption of "daily rates" for the postoperative rehabilitation. The latter were reported 84 € and 104 € per day for outdoor and indoor rehabilitation, respectively, but must be assumed to differ notably among health care insurers and providers. Whether the 20% difference in direct costs is representative for the actual saving potential between indoor and outdoor care remains open for discussion. For example, the economic advantages of outdoor rehabilitation may be notably reduced by the additional consideration of indirect costs due to transportation, but may also remarkably improve because of earlier return to work and the associated savings in work incapacity reimbursement. However, to avoid the imputation of a series of further model assumptions on indirect cost profiles, the above retrospective pilot study only restricted to central assumptions on direct costs from the health care insurer's perspective. On the other hand, this model assumption had great impact on the ICER estimate, which was explicitely based on the median cost difference of 420 € drawn from this assumption. This difference means a 5% difference between the overall direct cost profiles of indoor versus outdoor care; it appears to correspond to the 5% difference in clinical benefit estimates. Variation of the model parameters 84 € and 104 € means proportional variation of this gradient in cost / benefit reduction.

The above sensitivity analysis points to a further result determinant, which affords critical consideration, that is the dominating impact of matching: Note, that the matched pair evaluation revealed an "intra-pair" difference of only 0.77 QALYs, thereby implying a rather comparable benefit profile among the rehabili-

tation alternatives from a clinical point of view. The matching was introduced into the design to allow for the comparison of two un-randomized samples in a more homogenous manner by eliminating the confounding impact of prognostically relevant cofactors like age or working state. However, whether the above difference of only 0.77 QALYs is rather a result of deconfounding or rather overmatching remains open for discussion. In particular, a selection bias might have been introduced into the date already before the post hoc matching, since out-patient offers are known to be primarily requested by "active patients". Furthermore it cannot be assured, whether the matching partners underwent clinically equivalent or at least comparable formats of intervention: indoor and outdoor rehabilitation concepts may, for example, crucially differ in the amount of included physiotherapy offers and self-practicing requirements. Although it may be assumed, that the rehabilitation concepts after THA are rather stringent and therefore comparable among different providers, the direct comparability of matched partners can only be hypothesized. In summary, subsequent prospective investigations are necessary, which should try to randomize appropriate patients onto the indoor and outdoor rehabilitation alternatives, therapeutic elements of which would have to be provided in a comparable and standardized manner.

Conclusion

This matched pairs pilot investigation did not demonstrate a superior cost effectiveness from a health care insurer's perspective for indoor rehabilitation after total hip arthroplasty when compared to its outdoor rehabilitation alternative. This economic finding is complemented by a rather small difference in clinical benefit. Prospective investigations, which should randomize the rehabilitation alternatives onto appropriate patients and additionally involve indirect cost estimates for cost effectiveness adjustment, are necessary to confirm the above pilot investigation's findings.

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References

1. Antoniou J, Martineau PA, Filion KB, Haider S, Zukor DJ, Huk OL, Pilote OL, Eisenberg JL. In-hospital cost of total hip arthroplasty in Canada and the United States. J Bone Joint Surg Am 2004, 86A: 2435-2439
2. Bischoff-Ferrari HA, Lingard EA, Losina E, Baron JA, Roos EM, Philips CB, Mohamed NN, Barrett J, Katz JN. Psychosocial and geriatric correlates of functional status after total hip replacement. Arthritis Rheum 2004, 51: 829-.835
3 Blanchard C, Feeny D, Mahon JL, Bourne R, Rorabeck C, Stitt L, Webster-Bogaert S: Is the Health Utilities Index valid in total hip arthroplasty patients? Qual Life Research 2004, 13: 339-348
4. Brauer CA, Rosen AB, Olchanski NV, Neumann PJ. Cost-utility analysis in orthopedic surgery. J Bone Joint Surg Am 2005; 87: 1253-1259
5. Brander VA, Malhotra S, Jet J, Heinemann AW, Stulberg SD. Outcome of hip and knee arthroplasty in persons aged 80 years and older. Clin Orthop Relat Res 1997; 345: 67-78
6. Brooks R. EuroQol: the current state of play. Health Policy 1996; 37: 53-72
7. Bozic KJ, Saleh KJ, Rosenberg AG, Rubash HE. Economic evaluation in total hip arthroplasty: analysis and review of the literature. J Arthroplasty 2004; 19: 180-189
8. Chang RW, Pellisier JM, Hazen GB. A cost-effectiveness analysis of total hip arthroplasty for osteoarthritis of the hip. JAMA 1996; 275: 858-865
9. Chapman RH, Stone PW, Sandberg EA, Bell C, Neumann PJ. A comprehensive league table of cost-utility ratios and a sub-table of "panel-worthy" studies. Med Decis Making 2000; 20: 451-467
10. Faulkner A, Kennedy LG, Baxter K, Donovan J, Wilkinson M, Bevan G. Effectiveness of hip protheses in primary total hip replacement: a critical review of evidence and an economic model. Health Technol Assess 1998; 2: 1-133
11. Fisman DN, Reilly DT, Karchmer AW, Goldie SJ. Clinical effectiveness and cost-effectiveness of two management strategies for infected total hip arthroplasty in the elderly. Clin Infect Dis 2001; 32: 419-430
12. Fitzgerald JD, Orav EJ, Lee TH, Marcantonia ER, Poss R, Goldman L, Mangione CM. Patient quality of life during the 12 months following joint replacement surgery. Arthritis Rheum 51, 100-109
13. Fitzpatrick R, Shortall E, Sculpher M, Murray D, Morris R, Lodge M, Dawson J, Carr A, Britton A, Briggs A. Primary total hip replacement surgery – a systematic review of outcomes and modelling of cost-effectiveness associated with different prostheses. Health Technol Assess 1998; 2: 1-64
14. Fitzpatrick R, Norquist JM, Jenkinson C, Reeves BC, Morris RW, Murray DW, Gregg PJ. A comparison of Rasch with Likert scoring to discriminate between patients' evaluations of total hip replacement surgery. Qual Life Research 2004, 13: 331-338
15. Garellick G, Malchau H, Herberts P, Hanssson E, Axelsson H, Hansson T. Life expectancy and cost utility after total hip replacement. Clin Orthop Relat Res 1998; 346: 141-151
16. Gillespie WJ, Pekarsky B, O'Connell DL. Evaluation of new technologies for total hip replacement – economic modelling and clinical trials. J Bone Joint Surg Br 1995; 77: 528-533
17. Krummenauer F, Landwehr I. Incremental cost effectiveness evaluation in clinical research. Eur J Med Res 2005; 10: 18-23
18. Lavernia CJ, Guzman JF, Gachupin-Garcia A. Cost-effectiveness and quality of life in knee arthroplasty. Clin Orthop Relat Res 1997; 345: 134-139
19. Laupacis A, Bourne A, Rorabeck C, Feeny D, Wong C, Tugwell P, Leslie K, Bullas R. Costs of elective total hip arthroplasty during the first year – cemented versus noncemented. J Arthroplasty 1994; 9: 481-487

20. McGregor AH, Rylands H, Owen A, Dore CJ, Hughes SP. Does preoperative hip rehabilitation advice improve recovery and patient satisfaction? J Arthroplasty 2004, 19: 464-468
21. McKenzie L, Vale L, Steams S, McCormick K. Metal on metal hip resurfacing arthroplasty – an economic analysis. European Journal of Health Economics 2003, 4: 22-29
22. Ostendorf M, vanStel HF, Buskens E, Schrijvers AJ, Marting LM, Verbout AJ, Dhert WJ. Patient-recorded outcome in total hip replacement – a comparison of five instruments of health status. J Bone Joint Surg Br 2004, 86, 801-808
23. Rissanen P, Aro S, Sintonen H, Asikainen K, Slatis P, Paavolainen P. Costs and cost-effectiveness in hip and knee replacements – a prospective study. Int J Technol Assess Health Care 1997; 13: 575-588
24. Shah AN, Vail TP, Taylor D, Pietrobon R. Comorbid illness affects hospital costs related to hip arthroplasty: quantification of health status and implications for fair reimbursement and surgeon comparisons. J Arthroplasty 2004, 19: 700-705
25. Weinstein MC, Siegel JE, Gold MR, Kamlet MS, Russell LB. Recommendations of the panel on cost-effectiveness in health and medicine. JAMA 1996; 276: 1253-1258

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