Hip Replacement in Rates: International Variation

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Cite this article: Hip Replacement in Rates: International Variation: Study. Am J Orth and Rhe. 2018; 1(1): 001-005.

Submitted: 10 May 2018; **Approved:** 24 May 2018; **Published:** **26** May 2018

ABSTRACT

Objectives: To summarise epidemiological data on the frequency of hip replacements in the countries of the developed world, especially in countries of the Organisation for Economic Cooperation and Development (OECD), and to investigate whether missing consensus criteria for the indication for total hip replacement (THR) result in different replacement rates.

Methods: Country-specific hip replacement rates were collected using the available literature, different data sources of national authorities, and estimates of leading hip replacement manufacturers.

Results: According to administrative and literature data sources the reported crude primary THR rate varied between 50 and 130 procedures/100 000 inhabitants in OECD countries in the 1990s. The crude overall hip implantation rate, summarising THR, partial hip replacement, and hip revision procedures, was reported to range from 60 to 200 procedures/100 000 inhabitants in the late 1990s. Moreover, large national differences were seen in the relationship between total and partial hip replacement procedures.

Conclusion: The reported differences in hip replacement rates in OECD countries are substantial. They may be due to various causes, including different coding systems, country-specific differences in the healthcare system, in total expenditure on health per capita, in the population age structure, and in different indication criteria for THR.

INTRODUCTION

Endorsed by the United Nations and the World Health Organisation, the years 2000–10 have been declared as the "Bone and Joint Decade" to draw attention to the increasing impact musculoskeletal conditions will have on world health as life expectancy increases. Total direct and indirect costs of musculoskeletal diseases have risen in the past 15 years, accounting for up to 1–3.5% of the gross national product in countries like Australia, Canada, the United States, or the United Kingdom.1–4 Radiographically defined osteoarthritis (OA) of the hip affects about 15% of people over 65 years in countries with a white population.5–7 Hip OA can lead to pain and impaired function and is known to be an important cause of disability in later life.

A number of studies have shown that total hip replacement (THR) effectively relieves symptoms of advanced hip OA and restores the loss of function.8–11 In addition, THR is more cost effective than other treatment options.12,13 Despite its major role in the treatment of OA, different indication criteria for THR seem to be applied. Our study aimed at examining THR in the countries of the developed world, especially Organisation for Economic Cooperation and Development (OECD) countries, and investigating whether the absence of consensus criteria results in different replacement rates.

METHODS

To obtain national THR rates we compiled data from the available scientific literature, different data sources of national authorities, and information from hip implant manufacturers. For information on further country-specific indicators, such as the age structure of the population or general healthcare costs, we also used the OECD Health Data File 1999.

Literature Review

Medline searches were performed for the time interval 1990–2000. We used "total hip arthroplasty", "total hip replacement", "total hip implant*", "total hip arthroplasty" combined with "incidence", "population-based", "osteoarthritis" as search terms. Only articles in English, German, or Dutch were considered. Further bibliographies and cross referencing of identified papers were used for completion of the studies.

The review includes only population based studies with a specified data source of performed THR. In most cases the data source was either a national register or the hospital records/operating theatre registers of an entire country, county, or smaller area. Publications with district data were only included in the study when national data were not available. Moreover, national or district THR rates were only considered if the reference population was the total population. If there were several publications pertaining to the same data source—for example, a national register, only the most recent one was taken into consideration.

Whenever possible the THR rates as provided in the publications were used. In some cases, only numbers of THR units were given in the publications. In these cases the OECD Health Data File 1999 was the data source for the population used to calculate THR rates. With few exceptions, only crude rather than age specific or age standardised THR rates are presented because only a few THR figures by age groups were recorded.

Information from national authorities

To get information on national data of THR rates we performed a survey among national authorities. We asked in a standardised questionnaire for annual rates, or, alternatively, absolute numbers of primary THR and overall hip replacements (sum of primary THR, partial hip replacement, and hip revision procedures) for the years 1985, 1990, 1995, and the most recent year with available data. As OA is the main diagnosis requiring THR, we also asked for hospitalisation rates due to OA (ICD-9: 715). Additionally, we requested further information on the data source (that is, the coding system, National Register, percentage of the national hospitals) and, if available, more detailed data such as age- or sex-specific hospitalisation rates.

This questionnaire was sent to national authorities of all OECD countries except Korea and Mexico, because no pertinent address could be identified in these countries. Additionally, we got in touch with organisations in Singapore as a developed Asian country. We also contacted all organisations mentioned above; overall, more than 90 institutions in 30 countries. Non-responders were sent a maximum of two reminders. In addition, data of National Statistical Offices, National Health Ministries and other relevant national authorities published on the internet were analysed. Data on hospitalisation due to THR or OA rates, or both, were obtained from 23 countries. Data from two countries (Greece, Luxembourg) were not available in the form we requested, and authorities from one country required a prohibitive charge. The contacted institutions of four countries (Belgium, Italy, Netherlands, Turkey) reported a lack of access to the requested data. Swiss and German data were excluded because they might not have been representative for the country as only 50% of the Swiss and German hospitals reported data to the authorities.

Crude hospitalisation rates were calculated by relating annual numbers of events with population figures of the OECD Health Data File 1999 if necessary. The most recent year, for which population figures were available in this data source was 1997, and the 1997 figures were also used to calculate approximate rates for more recent years (1998, 1999).

Information from Hip Implant Manufacturers

We asked seven leading manufacturers of hip implants for their estimate of the hip joint replacement market in Europe, North America and in some Asean-Pacific countries. Four companies (Aesculap, Biomet, De Puy, Sulzer) provided the requested data. Generally, these computations are based on several data sources, such as information from industry participants, key academic conferences, national orthopaedic associations, statistical offices, market literature, or market intelligence services.

Most data pertained to "hip implant units" without further specification as primary THR, partial hip replacement, or revision procedures. Numbers of hip implants were again combined with population figures from the OECD Health Data File 1999 to estimate crude implantation rates.

These manufacturers' data were only included in this survey if they referred to the period 1997–99 and if at least data from two companies for one country were available.

National authorities in different countries and international orthopaedic companies do not always record the same data type. To demonstrate as much relevant information as possible, we present two end point criteria: national THR rates and overall national hip implantation rates. The latter summarise THR, partial hip replacement, and hip revision procedures.

RESULTS

Country-specific primary THR rates

Review of The Literature

Published crude annual primary THR rates for white people vary between 50/105 and 125/105 inhabitants (table 1). For the period since 1990 the annual THR rates were reported to be between 100 and 125 in Norway,14 Iceland,15 Sweden,16 and in the Netherlands,17 whereas for England,18 Australia,7 and the western part of Scotland19 the corresponding rate varied between 65 and 90. For some countries only earlier data were available. In the period 1988–90, the crude annual THR rate in Denmark was 82/105,20 in Finland 58/105,21 in Canada 50/105,22 and in Olmsted County (USA) 60/105.23 A study of ethnic groups within the cosmopolitan population of San Francisco (USA) showed large ethnic differences in the incidence of THR.24 THR rates for white subjects were two to 10 times higher than that of any other ethnic group (black, Hispanics, Asians). For the residents of Maryland (USA) the annual THR rate was reported to be 59/105 in the years 1985–87 with a black to white ratio of 0.73.25

Table 1: Annual primary THR rates/105 inhabitants: scientific literature data

As shown in table 1 primary OA is the main indication for more than 65% of all primary THRs performed in the Scandinavian countries, Scotland, and Australia. In different ethnic groups of San Francicso the proportion of OA among the indication for THR varies between ethnic groups. The highest proportion was found for white people (66%), followed by black people (55%), Hispanics (54%), and Asians (<29%). Among Japanese men and women living in Hawaii, only 30% and 36% of all THR were performed because of OA.26

Below the age 50, THR rates were low and quite similar for all ethnic groups of Hawaii (white, Japanese, Chinese, Hawaiians, Filipino) (web extra fig W1).26 For those older than 50 years of age, the white population has markedly higher THR rates than the other ethnic groups. The age-specific THR rate of white people increases steadily up to the age of 75–79 years and declines thereafter (web extra fig W2).27,28 These observations from England and the United States are consistent with data in western/northern European countries and in Canada.15,18,23,29

National Health Authorities Data

According to information obtained from the contacted national authorities the crude national (primary) THR rate in 1998 varied between 8 and 135/105 inhabitants (table 2). France and the Scandinavian countries reported a high rate of primary THR with more then 90 procedures per 105 inhabitants. Markedly lower rates were registered in Ireland with 63 primary THR/105 inhabitants and in the United States with 53 primary THR/105 inhabitants. Only eight THR/105 inhabitants were reported for Singapore. The reported THR rates from Hungary and Singapore do not permit a further differentiation between primary and revision arthroplasty procedures. Therefore, primary THR rates are likely to be slightly lower for these countries.

Table 2

Annual primary THR rates/105 inhabitants: national health authorities data

Over the past decade differences in the development of the national annual THR rates are observable. Whereas in Norway and Sweden, countries with a high THR rate in 1990, the annual primary THR rate increased only slightly between 1990 and 1998, the Scottish and Finnish rates which were low in 1990 increased by 70% and 40% during this period, respectively.

Country-specific overall hip implantation rates

National Health Authorities Data

For overall hip implantation, defined as THR, partial hip replacement, and hip revision procedures combined, the national authorities reported for 1998 crude rates between 27 and 192 operations per 105 inhabitants (web extra table W1). In accordance with the primary THR data the French rate was the highest with 192 hip implants/105 inhabitants, whereas in most other western and northern European countries 100–150 hip implant procedures/105 inhabitants were performed. Lower national hip replacement rates were reported from eastern European countries and from Portugal. With fewer than 30 hip implantations/105subjects the inhabitants of Singapore and the pacific people of New Zealand had the lowest hip implantation rates.

The large national differences in the ratio of total to partial hip replacement procedures are remarkable. In Hungary, for example, this ratio is reported to be 10:1, in Australia nearly 3:1, in England 2:1, in the United States of America slightly over 1:1, and in Singapore 1:2.5 (data not shown).

As the Norwegian data do not include the hemiprostheses and the Polish and the Portuguese data do not include the hip revision procedures, the reported implant numbers of these countries are likely to underestimate the hip replacement procedures actually performed.

Information from Hip Implant Manufacturers

According to these data Switzerland, France, Austria, and Germany have the highest hip implantation rates world wide (table 3). Estimations of country-specific hip implantation rates vary between 100 and 160 procedures per 105 inhabitants for many northern and western European countries. Sixty to 100 hip procedures per 105 inhabitants were reported for southern European countries and for the United States, followed by Japan with 45–74 hip implants/105 inhabitants.

Table 3: Hip implantion rates according to information from hip implant manufacturers

Country-specific OA rates

The reported annual hospital discharge rates for OA varied between 200 and 320 discharges/105 inhabitants in 1995 or later for most of the western and northern European countries and some eastern European countries like Hungary and the Czech Republic. Higher rates were reported for Austria and Finland with more than 400 discharges/105 inhabitants, and lower rates (100–150 discharges/105 inhabitants) for the United States, New Zealand, and Poland. Fewer then 100 discharges due to OA/105 inhabitants were registered in Portugal, Spain, Japan, and Singapore in 1995.

Country-specific general healthcare costs

In 1997 total expenditure on health per capita (purchasing power parity) varied between $400 and $4000 (fig 1). By far the highest expenditure on health was reported for the United States with $4095 per capita, followed by Switzerland ($2611) and Germany ($2364). Most Scandinavian countries and some western European countries like France, the Netherlands, and Belgium spent between $1750 and $2050, New Zealand, the United Kingdom, and most southern European countries between $1000 and $1500. Less than $1000 were spent in 1997 in eastern European OECD countries.

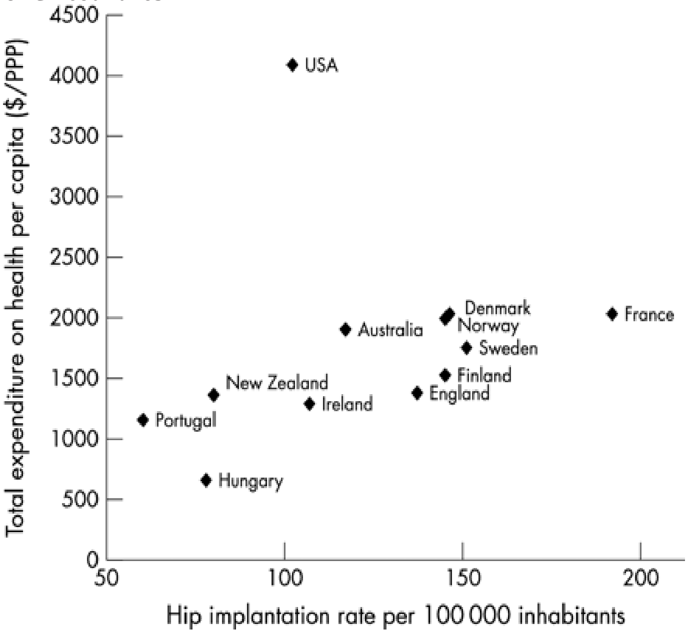

Figure 1: Hip implantation rate per 100 000 inhabitants and total expenditure on health per capita (1998).

DISCUSSION

THR is a common orthopaedic procedure in the elderly. However, detailed epidemiological data on the frequency of hip replacement are rare. We therefore collected all available country-specific hip replacement data for the OECD countries using different data sources.

Rates of THR varied considerably between the contacted OECD countries with a predominantly white population. The crude national annual primary THR rates as reported by national authorities varied between 50 and 140 procedures/10^5 inhabitants. These data are consistent with publications based on hospital records or on administrative data sources.[7,14–20,23] As most data come from Scandinavian or English speaking countries, the variation of crude THR rates may even be greater between all of the OECD countries. The reported low hip implantation rates for Poland and Portugal, the very low Spanish and Portuguese hospital discharge rates with the diagnosis of OA, and the low numbers shown by manufacturer data for hip implantation procedures in Italy and Spain may be indications of relatively low THR rates in some eastern and southern European countries. High levels of hip implants indicated by several companies for Switzerland and Germany in combination with the high total expenditure on health per capita in these countries may indicate high primary THR rates. White men and women have substantially higher THR rates than all other ethnic groups. The low THR rates of Asian people living in San Francisco and Hawaii[24,26] are consistent with the reported low national THR rates of residents of Singapore and the low hip implantation rate of the pacific people of New Zealand, indicating different prevalence of OA in different ethnic groups. However, other factors such as different access to health care by ethnicity may also play a part.

Although we attempted to acquire comparable data from each country, this was not always possible, because of different types of documentation systems in national authorities, orthopaedic societies, and implant manufacturers. Other restrictions and uncertainties were the different national coding systems, the scarcity of information about procedures performed in the private healthcare sector, uncertainty about the quality of the data—namely, its completeness, comparability over time, etc. So even when comparing one single procedure—for example, primary THR, the compilation of comparative data within different countries is difficult.

Most national primary THR rates are based on different coding systems. The three digit ICD-9-CM code, which is used for example in the United States and in Ireland, allows differentiation of THR, partial hip replacement, and hip revision. The specification of the French coding system that is derived from the American DRG, or of the OPCS4 code used in England, Scotland, and Wales is more detailed. Furthermore, no detailed information on hip revisions is available for Singapore and Hungary, so that the reported THR data of these countries probably include the revision procedures. Additionally, the variety of information about procedures performed in the private healthcare sector influences national THR rates as well. Singapore with a central claims processing system, the Scandinavian countries with National Hip Arthroplasty Registries, and France with the recently installed Medical Information System include public as well as private hospitals in their statistics. However, for many other countries the completeness of the data has to be questioned. In England the Hospital Episode Statistics, which is the data source of the reported THR rates, covers all patients treated in hospitals of the National Health Service (NHS) and includes private insurance payment. However, in addition to the reported 32 800 primary THR performed in NHS hospitals about 11 000 THR procedures are carried out in the private sector.[27] Similarly, the reported hip implantation data of Portugal and of New Zealand refer only to the National Service Hospitals without further information on the THR procedures performed in private institutions. Consequently, the true incidence of THR or of hip implantations is underestimated in these countries.

As the age-specific THR incidence steadily increases in white people with age from 50 up to 75–79 years and declines thereafter, age standardised incidence rates are needed for a direct comparison between populations in order to eliminate differences in country-specific age structures. OECD countries with a relatively young population—defined as <12% of the total population older than 65 years in 1997—are Iceland, Ireland, Poland, New Zealand, and Australia. OECD countries with a relatively "old" population—defined as >15% of the total population older than 65 years—are, for example, Sweden, the United Kingdom, France, and Norway. Ingvarsson et al demonstrated the implications of different population age structures by comparing Swedish and Icelandic THR rates.[15] On the basis of crude incidence rates there seemed to be no difference between the two countries, but after age standardisation THR incidence was at least 50% higher in Iceland than in Sweden. In the present paper we were unfortunately unable to perform age standardisation, because the few age-specific THR data obtainable were based on different age strata. Comparisons between countries with different age structure should therefore be interpreted with caution.

Besides limitations in the completeness and the comparability of the data, differences in the economic structure may influence national hip replacement rates as well. In 1997 great differences in total expenditure on health per capita ($ purchasing power parity) were reported in OECD countries. Countries with low expenditure on health typically have low national hip implantation rates, whereas high expenditure on health does not always correlate with high hip implantation rates. Despite comparable high expenditure on health per capita and a similar population age structure in France and the Scandinavian countries, major differences in hip implantation rates per 100 000 inhabitants were seen between these countries. In comparison, despite the highest expenditure on health per capita in the USA, national hip implantation rates are surprisingly low, even considering the young age structure and the limitation of the data to the public sector.

Our results indicate major variation in hip replacement rates between developed countries which are unlikely to be explained solely by differences in OA rates, age structure, or health expenditure per capita, underlining the need for commonly agreed indication criteria.

ACKNOWLEDGMENTS

Dr H Merx was supported by the Bertelsmann Foundation within the project “Degenerative Joint Disease”.

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Figure 9: Scattergram shows no relationship between the foramina diameter and the total length of the humerus.

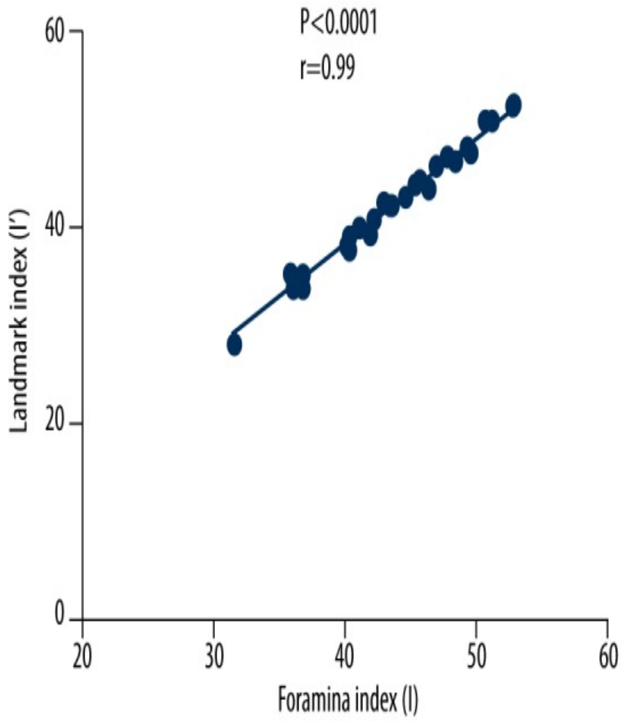

Figure 10: Scattergram shows a strong correlation between the foramina index (I) and the landmark index (I′).

The availability of full cadavers allowed comparison of data between both sides of the body. The statistical data for the left and right sides are presented in Table 2. Paired t-tests were performed for diameter, length, and nutrient foramina index. Specimens with absent or two foramina were excluded. No significant differences were observed between the left and right sides for diameter, length, and nutrient foramina index (p values: 0.713, 0.431, and 0.278, respectively).

Table 2: Statistic data of nutrient foramina on different sides.

	Mean number	Mean diameter (mm)	Mean horizontal distribution	Mean TL (mm)	Mean I (%)	Mean I′ (%)
L	1.05	1.13±0.31	20.99±17.16%	305.29±33.38	45.03±3.52	43.66±3.78
R	1.16	1.10±0.34	16.21±24.92%	304.95±16.31	42.61±5.79	40.97±6.33

DISCUSSION

The arrangement of the diaphyseal nutrient foramina in the long bones usually follows a defined pattern in which the foramina are located on the flexor surface of the bones (anterior in the upper limbs and posterior in the lower) [15 23]. Dissection revealed that the main blood supply to the shaft of the humerus enters through a restricted surface area on the anteromedial aspect of the distal half of the shaft. This finding was consistent with most previously reported studies [1,2,4,5,15,23].

Among these studies, only Carroll and Forriol investigated the relationship between nutrient foramina and the surrounding muscles. Carroll measured the distances from the foramen to the apex of the deltoid insertion [15]. Forriol found that the location of the nutrient foramina was below the insertion of the coracobrachialis muscles [4]. Because the main nutrient arteries enter the humerus medially, it is appropriate to observe the relative locations between the nutrient foramina and the medial muscles. Our findings were consistent with those of Forriol. We believe this information will assist surgeons in locating the nutrient foramina during surgery, thereby preserving the circulation in the region. Kizilkanat suggested a direct relationship between the position of the nutrient foramina and a continuous blood supply because the foramina were always located near major muscle attachments [2]. This may also explain the location of the nutrient foramina in the diaphyseal humeri.

The observation that the majority of the humeri had a single nutrient foramen is consistent with most studies, including those conducted with different races [1,2,4,5,13,15,23]. As we observed, some authors also reported a small number of humeri with no foramina [5,22–24]. Nutrient arteries divide into ascending and descending arteries after entering the cortex of the bone [10]. In the humerus, this division may take place outside the cortex, with each branch having its own canal and nutrient foramen [1]. This could explain the humeri with two foramina that were observed by our team and by other researchers. In Mysorekar's study, 42% of the specimens (from Hindu patients) had more than one nutrient foramen, and 19% of the foramina were found in the spiral groove [22]. Because the other two authors from India reported conclusions similar to those of most studies, we rejected the idea that the differences observed could be attributed to race; instead, we surmised that Mysorekar might have noted the foramina of both the main and accessory nutrient arteries on the basis of Laing's definition [1]. Laing and Forriol reported that the main nutrient foramina were always found on the anteromedial surface of the bone [1,4]. Laing also stated that one or several accessory arteries of the humerus arise from the profunda brachii and enter the posterior surface in the spiral groove [1]. This can explain the humeri that were observed to have more than two foramina or foramina on the posterior surface. The accessory nutrient arteries varied in number, and their foramina were too small to identify with the naked eye [1,4]. Therefore, the main nutrient foramina are more clinically meaningful during surgery.

Previous studies have focused largely on the direction and orientation of the nutrient foramina. Some authors have proposed theories to account for the generally consistent direction of the nutrient foramina as well as the anomalously directed ones. Among these, the "vascular theory" proposed by Hughes and favored by most authors offers the best explanation for both the normal nutrient foramina and anomalies [11,23,24,27,28]. Hughes stated that the foramina were directed away from the growing end, which was the proximal end in the case of the humerus, and anomalous foramina are frequently observed in the femur but rarely occur in the radius and other bones. In his article, Hughes also noted that anomalous foramina were extremely rare in the human femur but were common in other species [28]. In the present study, we observed that the foramina were consistently directed toward the elbow. Previous authors have demonstrated that the obliquity and location of the nutrient foramina are not significantly correlated with the known bone age [22,24], which supports the vascular theory.

The diameter of the nutrient foramina in human long bones has been reported in only a few papers. Because there have been no reference data on the humerus to date, the results reported here are novel data. In some studies, when a bone had more than one foramen, the larger was considered the main foramen [15,22]. Mysorekar reported reciprocity between foraminal sizes in humeri with two foramina [22]. In the studies of Kizilkanat and Longia, on the other hand, some humeri were found to have two nutrient foramina, neither of which was dominant and with no reciprocity observed in their size [2,23]. In our series, we observed one humerus that had two foramina with the same diameters (Specimen 10). We also observed no relationship between the foraminal size and their proximal or distal location. Some authors discussed the concept of acquired disposition [15,25]. Carroll observed a significantly greater proportion of large foramina on the right side and attributed this to the increased function of the right arm, which is usually dominant [15]. Sendemir proposed that the difficult living conditions experienced by warriors might play a role in the differences observed between ancient and modern humans after studying the lower limb long bones of 305 unearthed ancient skeletons [25]. We analyzed the data from our sample and found no significant differences between left and right sides (p=0.713). Because all of our specimens were Chinese, this observation may