

## PATIENT CHARACTERISTICS THAT AFFECT THE OUTCOME OF TOTAL HIP ARTHROPLASTY: A REVIEW

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**OBJECTIVE:** To review the literature regarding patient factors pertinent to the outcome of total hip arthroplasty (THA).

**DATA SOURCES:** MEDLINE from 1966 onward (key words “hip prosthesis” and “treatment outcome”) and literature previously known to the authors and cited in papers from all sources.

**STUDY SELECTION:** All identified studies were included provided the methodology permitted assessment of the effect of patient factors and a clear outcome was defined (either prosthesis survival or specific functional outcomes).

**DATA EXTRACTION:** The patient factors, methods and outcomes described in each paper were summarized on a data extraction form.

**DATA SYNTHESIS:** All data were reviewed by one author. This process was repeated by a second author, and the findings were reviewed by the remaining 2 authors to verify the findings. The best functional outcomes and prosthesis survival rates were reported among patients who were between 45 and 75 years of age, weighed less than 70 kg, had strong social support, had a higher educational level, had better preoperative functional status and had no comorbid disease.

**CONCLUSION:** Important research remains to be done to examine the magnitude and interaction of patient factors on the outcome of THA.

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**OBJECTIF :** Revoir les écrits portant sur les facteurs liés aux patients qui ont trait à l'issue d'une arthroplastie totale de la hanche (ATH).

**SOURCES DE DONNÉES :** MEDLINE à compter de 1966 (mots clés «hip prosthesis» et «treatment outcome») et publications connues des auteurs et citées dans des documents provenant de toutes sources.

**SÉLECTION D'ÉTUDES :** Les auteurs ont inclus toutes les études repérées, à condition que la méthodologie permette d'évaluer l'effet des facteurs liés aux patients et qu'on ait défini un résultat clair (survie de la prothèse ou résultat fonctionnel précis).

**EXTRACTION DES DONNÉES :** Les auteurs ont résumé sur une formule d'extraction des données les facteurs liés aux patients, les méthodes et les résultats décrits dans chaque document.

**SYNTHÈSE DES DONNÉES :** Un auteur a examiné toutes les données. Un deuxième a répété l'exercice et les deux autres ont examiné les résultats pour les vérifier. Le meilleur résultat fonctionnel et le meilleur taux de survie de la prothèse ont été signalés chez les patients âgés de 45 à 75 ans, qui pesaient moins de 70 kilos, bénéficiaient d'un solide appui social, avaient fait des études plus poussées, avaient un meilleur statut fonctionnel avant l'intervention et n'avaient pas d'affection comorbide.

**CONCLUSION :** Il reste d'importantes recherches à faire pour examiner l'ordre de grandeur des facteurs liés aux patients et leur incidence sur l'issue de l'ATH.

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The reported outcomes for total hip arthroplasty (THA) have ranged from 47% for “good” function at 4 years (with a 28% revision rate)<sup>1</sup> to 98% “good” or “excellent” functional outcome at 5 years (with a 2% revision rate).<sup>2</sup> In this regard, surgeons have focused primarily on the type of prostheses and surgical technique as the determinants of patient outcome, paying less attention to how patient characteristics might affect the outcome of THA.<sup>3</sup> However, extreme variability in functional outcomes and revision rates exists even within groups implanted with the same prosthesis and within the same institution. Therefore, it is important to look beyond the prosthetic factors to determine whether patient factors, such as age, employment history and comorbidity, may alter the likelihood of a positive outcome.

Establishing that patient characteristics affects the outcome of THA has 4 important implications. First, the information may help surgeons predict those patients who will not do well after THA, so it may be used to more accurately advise individual patients of the risks and benefits of the procedure. Second, surgeons may use this knowledge to evaluate the patient characteristics of published studies and decide if the study population matches their own. Third, information about the prognostic effect of patient characteristics could be used to plan prospective clinical trials. Finally, the characteristics of the patient population may be helpful in explaining conflicting results between studies (e.g., by making post-hoc adjustments for case mix).

The purpose of this study was to review the orthopedic literature to determine the effect of patient characteristics on the outcome of THA. The objectives were: (1) to heighten clinicians’ awareness of the patient factors that may be associated with good or

poor outcomes after THA; (2) to suggest, whenever possible, the various ways in which these patient factors mediate outcomes; (3) to highlight areas of controversy; and (4) to provide the impetus, justification and focus for future research into patient factors predictive of outcome after THA.

## MATERIALS AND METHODS

Meta-analysis<sup>4</sup> was considered a preferable methodology to meet the objectives of this study. However, this particular body of literature contains several methodologic flaws. First, consistency of outcomes is lacking.<sup>4</sup> For example, some studies reported improvement in pain, whereas others assessed outcome in terms of functional disability or survival of the prosthesis. To compound the problem of comparable outcomes further, each of the 3 most common measures (pain, physical function and survival of the prosthesis) was defined in many different ways (e.g., survival defined by symptoms, radiographic evidence of femoral or acetabular failure, or revision rates). Second, patients were assessed at different times.<sup>5</sup> The effect of patient characteristics on outcome may depend on the time at which outcome is assessed. For example, the level of physical activity may not have any effect on the revision rate at 2 years but may increase the likelihood of revision at 10 years. Third, we found few studies that were designed specifically to investigate the effect of patient characteristics. The optimal design to evaluate the impact of patient factors is a descriptive study of the natural history of outcome after THA in which all other factors (e.g., surgeon and type of prosthesis) are held constant. Such studies are rare, thus the effect of patient factors could only be inferred from intervention studies designed to assess differences between prosthesis types. Because

these studies were designed for a different purpose, the sample sizes were not sufficient to determine the effects of multiple patient factors. Thus, it was not possible to use meta-analysis methodology to determine how patient characteristics affect THA outcomes. This observation is similar to the findings of a previous study, that attempted a meta-analysis of the surgical management of lumbar spinal stenosis.<sup>6</sup> However, the question of how patient characteristics influence the outcome of THA remains important. Therefore, we addressed the objectives of this paper by a comprehensive review of the literature.

Papers for review were identified by a MEDLINE search from 1966 onward using the terms “hip prosthesis” combined with “treatment outcome.” In addition, references from papers identified in the MEDLINE search were also considered for inclusion. From this pool of references, papers were selected for inclusion if they contained data on the effect of patient characteristics on the outcome of THA. Furthermore, because this paper was not intended to be an exhaustive review of all potential prognostic factors, we reviewed only those with a high level of clinical relevance: age; gender; weight; marital status and social support; socioeconomic status, education and ethnicity; disease type; preoperative functional status and activity level; and the presence of comorbid diseases.

Two outcomes were considered in this review: physical function (defined as limitations in activity) and prosthesis survival. Physical function is important because its improvement is a primary goal of THA. Prosthesis survival was included because it is the most commonly reported outcome. In this paper prosthesis survival is defined, whenever possible, as the absence of a need for revision surgery (revision is

the least controversial definition and the most comparable across studies).

## FINDINGS

The MEDLINE search identified 159 articles. We restricted our attention to 40 articles by excluding those that did not evaluate the effect of patient characteristics on the outcome of musculoskeletal conditions and those that did not include primary data (e.g., reviews and editorials).

### Age

The average patient who undergoes THA is between the ages of 64 and 67 years.<sup>1</sup> However, THA has been performed at opposite ends of the age spectrum, from adolescents<sup>7</sup> to patients as old as 100 years.<sup>1</sup> The majority of studies that examined the effect of age found that increasing age is associated with poorer functional outcome.<sup>1,8-10</sup> Pettine, Aamlid and Cabanela<sup>1</sup> found that only 66% of THA patients over the age of 80 years were ambulating without pain at 5 years compared with 83% of patients 64 to 67 years of age. In addition, 2 studies have reported longer hospitalizations, higher complication rates and lower functional success rates in patients over 90 years of age.<sup>1,9</sup> An analysis of 435 patients by Schurman and colleagues<sup>11</sup> also demonstrated that patients over 75 years of age had higher revision rates than patients 52 to 75 years of age.

Younger patients are generally believed to have worse long-term outcomes<sup>12,13</sup> secondary to high expectations and high physical demands on their prostheses. Age less than 45 years has been associated with a poor prognosis in the majority of studies.<sup>7,12,14-19</sup> Sarmiento and colleagues<sup>16</sup> compared 105 patients younger than 50 years of age with 607 patients older

than 50 years of age on the basis of prosthesis survival. At an average of 7 years after THA, the younger group had a 90% prosthesis survival rate compared with 97% in the older group. Dorr, Takei and Conaty<sup>15</sup> assessed 43 patients less than 45 years of age and found a higher 5-year clinical failure rate (defined as significant pain or need for revision) among patients 14 to 30 years of age (35% clinical failure) compared with patients aged 30 to 45 years (22% clinical failure). Chandler and associates<sup>12</sup> found that 80% of the prosthetic problems in young patients were associated with the acetabular component.

One study refutes the conclusion that young patients have worse outcomes. Boeree and Bannister<sup>14</sup> reported 98% prosthesis survival at 7 years for 34 cemented THAs in patients less than 50 years of age (26% of whom had rheumatoid arthritis). Two other studies have evaluated the effect of age; however, the results led to different conclusions, depending on the outcome measure chosen. Klassen, Parlasca and Bianco<sup>7</sup> reported that 22% of 47 adolescent THA patients suffered major complications at an average follow-up of 4 years, although 85% had Harris hip scores of 80 points or more. Chandler and associates<sup>12</sup> reported a 57% "problem hip" rate (defined as prostheses requiring revision, showing roentgenographic evidence of migration or radiolucent lines suggestive of complications) for 29 patients less than 30 years of age. However, 77% of the sample had a Harris hip score of 80 or more. Chandler and associates therefore concluded that Harris ratings may be falsely negative in these patients, since the mean Harris hip score for the "problem hip" patients was 83 points.

Thus, patients at either end of the age spectrum (younger than 45 and older than 75 years of age) appear to

have a worse prognosis both for functional outcomes and prosthesis survival. The effect of age on the outcome of THA may, however, be partially confounded by other factors, including comorbidity, activity level, postoperative functional goals and type of disease.

### Gender

Research into the effect of gender on the outcome of THA is contradictory. Schurman and colleagues<sup>11</sup> found better prosthesis survival among women but attributed the differences in outcome to differences in body weight between men and women. However, even in populations in which obesity was not a factor, better prosthesis survival in women has been reported in most other studies.<sup>17,20,21</sup> In contrast, Surin and Sundholm<sup>22</sup> studied 695 patients who had 803 THAs and found that, after controlling for the effect of weight, men did not have a higher revision rate. Other studies found no gender difference in either prosthesis survival<sup>18,23</sup> or quality of life.<sup>24</sup> Finally, 1 study found that men had significantly better functional outcomes than women, as measured by activities of daily living.<sup>25</sup>

Thus, women may have better functional outcome and prosthesis survival, but the differences may be partially attributable to confounding factors.<sup>26</sup> Many factors, including educational level, age, marital status, weight, diagnostic groups and level of comorbidity, differ between male and female THA populations and may partly explain the observed relationship.

### Weight

Increased weight intuitively should be a risk factor for poorer outcome after THA because of the additional

stresses placed on the prosthesis leading to its failure. Studies evaluating the effect of weight on the outcome of THA, however, have often not considered the difference between mass and obesity. Weight or mass is an absolute measure (e.g., 75 kg), whereas obesity is a relative measure based on a standard determined in part by height (e.g., body mass index [BMI] in excess of 30). For example, a patient weighing 75 kg may place a significant stress on a hip prosthesis that may decrease the survival of that prosthesis. If the patient is a man and is 193 cm tall, he is not obese. The same weight for a woman who is 160 cm tall may have a greater detrimental effect on her physical function because of the added impact of obesity, although the absolute value of the load on the prosthesis is essentially unchanged. The majority of the studies have considered weight, rather than weight in excess of ideal body weight, such as is calculated by the BMI.

Many studies have reported that increased weight is associated with increased rates of prosthesis failure,<sup>12,18,20,27-29</sup> whereas others have found no effect of weight.<sup>23,30</sup> Surin and Sundholm<sup>22</sup> and Olsson, Jemberger and Tryggo<sup>29</sup> both found that patients weighing more than 80 kg were at significantly greater risk of prosthetic failure requiring revision. Schurman and colleagues<sup>11</sup> reported that weight was the most important risk factor for prosthetic failure and that the risk of such failure associated with very young and very old age was further increased by weight in excess of 68 kg. They concluded that "while body weight was predictive of failure, an analysis using body mass index was not."<sup>11</sup> Finally, 1 study reported that obesity was not a risk factor for perioperative morbidity<sup>31</sup> but did not evaluate longer term effects. Thus, increased weight appears to be related to a poor outcome.

#### Marital status and social support

Social support can be defined as those resources in a person's environment that enable that person to deal with life's physical and psychological stresses. Patients may be extremely disabled but maintain a high quality of life because they have social support. Surgery, such as THA, magnifies the need for support in the short term.

Greenfield and associates<sup>25</sup> found that married patients reported better functional outcomes after THA than unmarried patients. Other studies have shown that patients with better social support have lower dislocation rates<sup>24</sup> and higher postoperative quality of life.<sup>24,32</sup> In addition, the rheumatologic literature suggests that social support has a positive effect upon the health of patients with arthritis.<sup>33,34</sup>

Although not specifically evaluated on patients receiving THA, psychological variables such as depression, anxiety and coping style have also been shown to have an impact on functional impairment in patients with arthritis. In a study of patients with osteoarthritis of the hip or knee, higher levels of depression and anxiety were associated with greater functional impairment, as measured by the Sickness Impact Profile, and increased pain perception, as measured by the McGill Pain Questionnaire.<sup>35</sup> Depression has also been associated with decreased functional status in a study of (nonsurgical) patients with rheumatoid arthritis.<sup>36</sup> Weinberger, Hiner and Tierney<sup>34</sup> showed that an intervention as simple as 12 phone calls over a 6-month period to elderly patients with osteoarthritis increased their perceptions of social support and was associated with an improvement in their self-reported level of functioning. Thus, social support can influence patients' health and functioning.

#### Socioeconomic status, education and ethnicity

These may all have a significant bearing on lifestyle and thus may affect the prognosis after THA. Higher socioeconomic status may be associated with better functional outcome and prosthesis survival, because these patients have a greater opportunity to modify other risk factors. Ethnicity may also affect outcome because of the cultural expectations of a given group. For example, sitting on the floor is a required part of some religious practices; thus, THA patients for whom this is a cultural expectation, will experience significantly greater handicap than others in the cohort.

Socioeconomic status, educational level and ethnicity, however, are complicated, multifaceted characteristics whose effects are often difficult to separate and which have been infrequently evaluated in patients who undergo THA. These factors may affect access to health care, recognition that care is needed, communication with health care professionals, housing conditions, employment skills and opportunities, nutrition and compliance.<sup>33,37</sup> Poverty has been associated with poorer outcomes for many medical conditions and operative treatments.<sup>33</sup> In a longitudinal study of 75 patients suffering from rheumatoid arthritis who were followed up over a 9-year period, higher formal education did not affect functional status but was related to a reduced death rate.<sup>37</sup> In the only study investigating the effect of these factors on the outcome of THA, Greenfield and associates<sup>25</sup> found that those with high school education or beyond and Caucasians had significantly better scores for instrumental activities of daily living.

Employment status may also play a role in the outcome of THA. Employ-

ment associated with heavy labour has been reported to be more common among disabled subjects,<sup>38</sup> and a study of arthroscopic meniscectomy found that workers' compensation benefits were associated with much poorer short form (SF)-36 scores postoperatively.<sup>39</sup> No studies, however, have specifically evaluated this factor as a predictor of outcome after THA. Thus, although socioeconomic status, educational level and ethnicity may have an impact on health, the effect of these factors on THA is largely unknown.

### Disease type

The majority of patients who present as candidates for THA are suffering from osteoarthritis. Other disease processes necessitating hip replacement include rheumatoid arthritis (RA), avascular necrosis (idiopathic and post-traumatic), congenital deformity, femoral neck fracture and prosthesis failure. These patient groups may have different physical demands and expectations, particularly among RA patients who present for THA at a younger age, and when multiple joint involvement has generally resulted in decreased physical activity.

Although many studies have reported the results of THA in different disease groups, relatively few studies have directly compared the outcomes of THA between different diagnostic groups. Satisfactory clinical results have been reported for patients with RA after THA.<sup>15,17,19</sup> Severt and colleagues<sup>19</sup> reported a lessening of pain and improved physical function in 88% of RA patients 7 years after THA. Lachiewicz and associates<sup>20</sup> reported similar results for juvenile RA; however, 18% had radiologic signs of impending loosening, and 8% showed frank acetabular migration. In a review of THA performed on patients with Paget disease of the hip, satisfactory

functional results were reported in 70% to 85% of cases with an average follow-up ranging from 5.2 to 7.8 years.<sup>40</sup> Avascular necrosis (AVN) has been associated with poorer outcomes following THA.<sup>12,17,18</sup> Patients with osteonecrosis were reported to have only 52% good or excellent clinical results compared with 75% in patients with osteoarthritis.<sup>41</sup> Cornell, Salvati and Pellicci<sup>18</sup> reported a 42% failure in patients with osteonecrosis on average 7 years after THA, the most frequent failures being in patients with bilateral disease, alcohol abuse or weight greater than 60 kg. In contrast, functional scores (St. Michael's and Harris hip scores) obtained for 17 prednisone-dependent renal transplant patients were similar to a control group of 235 patients who underwent THA at an average follow-up of 48 months.<sup>42</sup> In addition, one of the largest studies of THA found no difference in outcome for patients with AVN on the basis of diagnosis alone and suggested that the high activity level in younger patients may have played a greater role than diagnosis in prosthesis failure.<sup>17</sup> Thus, the effect of diagnosis on outcome is uncertain, but patients with conditions such as AVN may adversely affect the outcome of THA.

### Preoperative functional status and activity level

How the patient functions preoperatively can also be expected to have an impact on postoperative functional outcome in both the short term and the long term. One study of 356 patients who underwent THA reported that the preoperative functional status was predictive of postoperative function.<sup>24</sup> This finding has recently been corroborated in 78 THA patients.<sup>43</sup> However, Schurman and colleagues<sup>11</sup> found that the preoperative Harris hip score was not prognostic for prosthe-

sis survival. Thus, good preoperative function appears to improve the likelihood of good postoperative function but has little value in predicting long-term prosthesis survival.

### Comorbidity

Comorbid conditions may have a significant impact on patient outcome after THA. For example, a patient who is unable to walk up a flight of stairs before THA due to hip disease may not show improvement after surgery due to secondary restrictions, such as ischemic heart disease. Comorbidity may also have an impact on expectations. For example, a patient who is bedridden may be very satisfied with pain relief in the absence of functional improvement, whereas such an outcome may be unacceptable to a patient without comorbid disease.

Comorbidity can be measured in several ways including Chandler's risk index,<sup>12</sup> the Charlson index,<sup>44</sup> Greenfield's comorbidity index,<sup>45</sup> (subsequently revised as the index of coexistent disease<sup>25</sup>), the Kaplan-Feinstein index<sup>46</sup> and the Duke Severity of Illness Checklist.<sup>47</sup> Comorbidity specific to THA patients has been classified by Charnley.<sup>48</sup>

Four studies have shown that decreased functional outcome is associated with comorbidity.<sup>8,10,25,43</sup> However, Liang, Cullen and Poss<sup>33</sup> reported that "older patients and patients with other medical conditions do as well as younger patients and patients with uncomplicated illness with regard to functional results, perioperative mortality and morbidity." Thus, the effect of comorbidity is controversial, but it appears to have a negative effect on postoperative functional status.

## DISCUSSION

Many patient factors appear to in-

fluence the functional outcome and survival of the prosthesis in patients who undergo THA. Although we have tried to summarize the literature on functional outcomes and prosthesis failures, weaknesses in the literature make discerning their effects difficult. These weaknesses included lack of comparable outcomes between studies, variability in the time at which outcomes were assessed and the absence of studies designed specifically to examine the effect of patient factors. Variability was also prevalent and problematic in the definitions used for patient characteristics (e.g., "young" age). In addition, those studies that specifically examined patient factors related to THA outcomes often examined the effect in isolation. As a result, little information was available on interactions among factors, and confounding effects may have influenced the results. Finally, many of the analyses were restricted to linear regression models. Not all factors have a linear relationship to the outcome, and thus the assumption of linearity may obscure an important effect.

Despite the limitations of the existing literature, several patient factors appear to affect the outcome of THA. Age appears to affect both functional outcome and prosthesis survival, with better results in patients between the ages of 45 and 75 years. Weight in excess of 72.6 kg appears to be related to poor outcome; however, BMI is not. Educational level, ethnicity and the presence of social support may influence patient health and functioning but require further investigation in THA. Preoperative function appears to correlate with postoperative function but has little value in predicting long-term survival of prostheses. Patients with osteoarthritis appear to have a better outcome than those with other diseases. Comorbidity appears to have a negative effect on postoperative function.

Research is required to determine the relationships and interrelationships between patient factors and outcomes. Any future research should have clearly defined outcomes that are consistent across studies. Linearity should not be assumed in the statistical analysis of new data sets, because not all factors have a linear relationship to the outcome. For example, age should not be assessed as a continuous variable because its effect may be negative at either end of the distribution (i.e., those under 45 years of age and over 75 years have worse outcomes than those in between). Both absolute weight and obesity should be considered so that their effects can be separated. Social support should not be inferred from marital status and requires a specific measure. Socioeconomic status should be measured by methods such as the British Census Scale<sup>49</sup> or classifications based on occupational prestige.<sup>50,51</sup> (Most of these socioeconomic indices rely in part on income, and income may not be an accurate marker for socioeconomic status in disabled and elderly populations.) Comorbidity may be the single factor with significant impact on THA outcomes, and several measures are available.<sup>12,25,44-48</sup> Disease type and previous THA are more easily classified. Multiple measures are available for the measurement of preoperative functional status.

In conclusion, several key factors predictive of functional outcome were found. The best functional outcomes and prosthesis survival rates are reported among those who are between 45 and 75 years of age, weigh less than 70 kg, have strong social support, are of higher educational level, have better preoperative functional status and have no comorbid disease. Further research is needed to clarify the magnitude of effects for these patient factors and to determine the nature of interactions

between patient factors. The periodic study of closed samples (i.e., the same 100 patients) at 2- to 5-year intervals is likely to provide more informative data than are currently being obtained from studying large groups at a single point in time.

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