Are we evaluating osteonecrosis adequately?

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Abstract

Purpose It is well recognised that to evaluate a patient with osteonecrosis of the femoral head (ONFH) adequately, it is necessary that the size of the infarct and the extent of femoral head joint involvement be indicated, in addition to the type or stage of the pathological process. The purpose of this study was to determine whether patients with ONFH are being evaluated adequately in studies published during the past 25 years and to see if any trends can be identified.

Methods Articles describing treatment of patients with ONFH, published between 1985 and 2011, were reviewed to determine the methods used to indicate the type and extent of pathology present on radiographs and magnetic resonance imaging (MRI) studies. The classification systems cited were identified and divided between those which indicated only the stage and those which indicated both stage and extent of involvement.

Results In 208 studies published between 1985 and 2011, specific classification systems were cited 237 times. During this period, non-quantitative systems, which only indicate stage, were cited 139 times (59 %) and quantitative systems, which indicate both stage and extent of involvement were cited 77 times (32 %). Between 2006 and 2011, non-quantitative systems were cited 30 times (48 %) and quantitative systems were cited 27 times (44 %).

Conclusions During the past 25 years there has been a trend towards the use of more comprehensive and effective methods of evaluating patients with ONFH. However, during the past five years, approximately half of the published studies continued to use limited, non-quantitative methods of evaluation. This should be brought to the attention of the orthopaedic community. Future investigations and publications

on ONFH should employ comprehensive methods of classification which include not only the stage of disease but also measurements of the size of the necrotic segment and the extent of femoral head and joint involvement.

Introduction

The evaluation and treatment of the younger patient with osteonecrosis of the femoral head (ONFH) remains one of the more controversial and frustrating problems confronting the orthopaedic surgeon. In addition to a thorough history and physical examination, the use of radiographs and magnetic resonance imaging (MRI) studies has become an integral part of the evaluation. It is now well established that it is essential to indicate both the stage and the extent of necrosis and joint involvement. This allows us to establish a prognosis, follow improvement or progression, compare different methods of treatment and determine the best way to manage a specific patient with osteonecrosis. Unfortunately, many of the articles on osteonecrosis published during the past 25 years continue to rely on older systems of staging which do not include the measurement of the lesion size or the extent of joint involvement. Thus, much important information is lost and the optimal evaluation and treatment of the patient is perhaps compromised. Therefore, the purpose of this study is to identify the classification systems used in the reporting of treatment of ONFH and to increase the awareness of the orthopaedic community towards the necessity of a quantitative classification system when treating, studying and reporting ONFH.

Materials and methods

We reviewed articles describing the treatment of patients with ONFH published between January 1985 and January 2011 in journals indexed in MEDLINE. The specific

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classification systems used were identified and divided into three groups: (1) those which effectively indicated both the stage and extent of involvement were considered “quantitative”; (2) those which indicated only the stage were considered “non-quantitative”; and (3) those which incompletely indicated the extent of involvement were considered “partially quantitative”.

In addition to evaluating the entire group of studies, the results were also broken down into an “early period”, studies published between 1985 and 2006 [1], and a more “recent period”, 2006–2011 [1–51], in order to compare differences between these two time periods and to see if any trends could be identified.

Results

During the 25-year period between 1985 and 2011, 208 studies on osteonecrosis (ONFH) of the hip were identified in which specific classification systems were cited 237 times [1–51]. Non-quantitative systems which indicated only stage of disease were cited 139 times (59 %), quantitative systems including size and extent of femoral head and joint involvement were cited 77 times (32 %) and systems with limited quantification were cited 21 times (9 %) (Fig. 1).

Between January 1985 and December 2005, 157 studies were reviewed in which specific classification systems were cited 175 times [1]. Sixteen major systems were mentioned, four of which accounted for more than 85 % of the reported studies. The most frequently employed system was that of Ficat and Arlet [2] which was used in 96 studies. The next most common were the University of Pennsylvania (UPenn) system [3–5] used in 31 studies, the Association Research

Circulation Osseous (ARCO) system [6–8] used in 18 studies and the system of the Japanese Orthopaedic Association [9, 10] used in seven studies. During this period, non-quantitative methods of classification were cited 109 times (62 %), quantitative systems were cited 50 times (29 %) and systems which included limited methods of quantification were cited 16 times (9 %). Among the major systems used, the system of Ficat and Arlet was considered non-quantitative, the systems of the UPenn and ARCO were considered quantitative and the system of the Japanese Orthopaedic Association was considered to have limited quantification (Fig. 2).

We subsequently identified 51 studies published between January 2006 and January 2011 which employed specific classification systems [1–51]. Eight systems were cited 62 times and three accounted for 89 % of citations. These included the classification of Ficat and Arlet 23 times, ARCO 15 times and the UPenn system 12 times. Non-quantitative systems were cited a total of 30 times (48 %), quantitative systems were cited 27 times (44 %) and systems with limited quantification were mentioned five times (8 %). Therefore, during the more “recent period” there appeared to be a trend towards the use of more comprehensive, quantitative methods of evaluation and staging compared to the earlier 20 years (Fig. 2).

Discussion

Our results show that despite the well-established fact that size and extent of the lesion in addition to stage play an important role in the outcome and prognosis of ONFH, most studies published over the past quarter century continue to

Fig. 1 Evaluation and classification of osteonecrosis of the hip in published reports from 1985 to 2011. Of 209 studies published between this time period, the majority (59 %) of studies employed non-quantitative classification systems that did not characterise the extent of femoral head or hip joint involvement

Fig. 2 Evaluation and classification of osteonecrosis: early (1985–2005) versus late (2006–2011). During the recent period, published reports on this subject have increased their use of quantitative classification systems compared to earlier published reports

use non-quantitative systems. Therefore, one of the purposes of this study is to increase awareness in the orthopaedic community to the importance of using a quantitative system when treating, studying and reporting on ONFH.

Proper classification of a disease is crucial to determining appropriate treatment, outcome and prognosis. The earliest system of classification was described in the 1960s by Arlet and Ficat [11] and included three specific stages. A fourth stage was added in 1970 [2] and this is the version most widely used today, although a preclinical stage 0 and a transitional stage were added later [12]. Neither MRI evaluation nor determination of lesion size were specifically included. In 1973, Marcus et al. [13] described six radiographic stages of osteonecrosis which were correlated with the patient's symptoms and with gross and histological findings. The extent of involvement was not measured. Subsequently, this classification system was modified by Urbaniak et al. [14] and by Enneking [15] to include MRI and later to include quantitative measurements [16].

As early as 1974, Kerboul et al. reported on the use of simple angular measurements of the necrotic lesion as seen on anteroposterior (AP) and lateral radiographs to determine the outcome of proximal and femoral osteotomies for the treatment of ONFH [17]. Several modifications of this technique were described subsequently using either plain radiographs or MRI images. They were used to supplement a non-quantitative classification system, such as that of Ficat and Arlet, rather than as an integral part of one [18–28].

The UPenn classification system, developed in the early 1980s, identified seven distinct radiographic stages and was the first to include both MRI and technetium bone scans and to describe specific measurements of lesion size and joint involvement [3–5]. In 1987, the Japanese Committee for Avascular Necrosis described a radiographic classification which indicated the location and type of lesion in stages II and III of the Ficat and Arlet classification [9]. This was subsequently modified to include stages I and IV in 2001 [10]. Finally, the Committee on Terminology and Staging of ARCO attempted to formulate a uniform terminology, diagnostic criteria and classification to be used internationally. In 1991, this committee endorsed the UPenn classification system [6]. The following year, the location of the lesion as described by the Japanese Committee was added [7], and in 1993, the classification was further modified to include only five rather than seven separate stages [8].

Correlation between outcome and extent of involvement

By the early 1990s it was well established that the extent of necrosis, in addition to the stage, was an important determinant of prognosis and management. In hips diagnosed prior to femoral head collapse, there is a direct correlation between outcome and the size of the necrotic segment. Once

femoral head collapse has occurred, the outcome is primarily correlated with the size of the collapsed segment and the degree of collapse. In the latter stages of ONFH, the extent of joint narrowing and acetabular involvement determine the prognosis and influence the type of treatment indicated [14, 17, 18, 22–24, 29–31].

It is also important to determine whether there has been progression or improvement in the extent of involvement when following a patient with osteonecrosis. Accurate measurements are needed to accomplish this. A direct comparison was made between the non-quantitative Ficat and Arlet system [1–51] and the quantitative UPenn system in evaluating 115 hips with osteonecrosis stages I–V. Radiographic progression was documented in 85 hips (74 %) when lesions were measured. However, only 58 hips (50 %) would have been classified as having progressed when evaluated by the non-quantitative method of Ficat and Arlet. For 45 hips in stage IV (femoral head collapse) further collapse was measured in 30 hips (66 %), whereas the Ficat and Arlet system indicated progression in only seven (15 %) (Fig. 3). These results show that a quantitative method of evaluation and staging can detect progression which is missed when lesion size and the amount of head collapse are not measured. Using the older, non-quantitative method of Ficat and Arlet, “progression” can be indicated only when it is great enough to cause a change from one stage to the next, which did not occur in many hips, although they did in fact undergo progression of the lesion (Fig. 4).

“Adequate evaluation”

We defined an “adequate evaluation” as one that included a comprehensive, quantitative method of examining radiographs

Fig. 3 Evaluation of progression of osteonecrosis: quantitative versus non-quantitative classification systems. Quantitative systems such as the UPenn classification system can detect disease progression with more sensitivity compared to a qualitative system such as that of Ficat and Arlet

Fig. 4 Composite radiographs showing progression of osteonecrosis from stages IVA through IVC over a period of 5 months time

and MRI studies which indicated not only stage of ONFH but also the size of the necrotic lesion and the extent of femoral head and joint involvement. If this was not documented, and the radiographic examination was non-quantitative, or only partially quantitative, the evaluation was not considered adequate.

It is understandable that the classification system of Ficat and Arlet remains popular and is still the most widely used since it was the earliest one published and is relatively simple, having only four stages. Investigators who began to compile data using this system, before the importance of lesion size was appreciated, have for the most part continued to use it. Recognising the limitations of this system, however, a number of authors have attempted to supplement it by adding linear or angular measurements of lesion size.

Different techniques have been described for determining these measurements and both radiographs and MRIs have been used [14, 17, 19–21, 25–27, 30–31]. This has been a useful addition, and in general these measurements do provide a degree of correlation with outcome. However, angular measurements can only give a rough estimate of the true size of an irregular three-dimensional lesion. They do not measure the amount of articular surface affected, the extent of the femoral head collapse or the degree of joint line and acetabular involvement. Neither do they indicate progression or resolution of the pathological process [33, 34]. Some have attempted to justify this approach by stating that obtaining more accurate measurements is technically too difficult [26, 33]; however, with advances in imaging technology, accurate three-dimensional measurements can be obtained with greater ease. In addition, it has been found that simple visual estimates of lesion size by experienced observers give close correlation with actual measurements and are quite useful clinically [29, 30, 34].

The ideal system for classification and staging

A detailed analysis of the major classification systems is beyond the scope of this study and has previously been reported [1, 18, 28, 33, 35, 36]. The ideal system should identify accurately the specific pathological changes present; be relatively simple, reproducible and unambiguous; measure the actual three-dimensional or volumetric size of the necrotic segment; indicate the amount of articular surface affected; measure the extent of femoral head collapse if present; and evaluate the degree of joint narrowing and acetabular involvement. These measurements should be an integral part of a single comprehensive system of evaluation and staging. It is to be noted that although no classification system is without some limitations and none has been universally accepted at the present time, the two systems that most closely meet these goals and provide “adequate evaluation” of patients with ONFH are the UPenn classification system [5] and the classification system proposed by ARCO [6–8].

Conclusions

Although the importance of an effective, quantitative system for staging and evaluating hips with ONFH has been recognised for many years, the majority of publications during the past 25 years continue to rely on older and non-quantitative systems. There has been a recent trend towards the use of more comprehensive, quantitative methods of staging, but during the past 5 years, nearly one half of the published reports on osteonecrosis of the hip continued to use limited, non-quantitative methods of evaluation. Thus, much important information is lost, and optimal evaluation and treatment of patients is perhaps compromised. This should be brought to the attention of the orthopaedic community, and it is important to emphasise the necessity of a quantitative classification system that takes into account the size and extent of the necrotic lesion, and joint involvement, in addition to the stage in order to adequately evaluate ONFH.

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APPENDIX A

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