

FUNCTIONAL OUTCOME AFTER ACETABULAR REVISION WITH ROOF REINFORCEMENT RINGS

Rina Jain, MD; Emil H. Schemitsch, MD; James P. Waddell, MD

OBJECTIVE: To evaluate the role for potential predictors of functional outcome after acetabular arthroplasty and to assess the results of revision with the use of a roof reinforcement ring.

DESIGN: A retrospective case series.

SETTING: A tertiary-care referral centre.

PATIENTS: Twenty-four patients (average age 72.7 years) who had undergone acetabular revision with a roof reinforcement ring were followed up for an average of 2.8 years.

INTERVENTIONS: Revision acetabular arthroplasty was performed using either the Mueller or Burch-Schneider roof reinforcement ring, bone grafting and a cemented polyethylene cup.

OUTCOME MEASURES: A modified Harris hip score (range of motion omitted), the SF-36 health survey and the Western Ontario McMaster (WOMAC) osteoarthritis index measured outcome. Multivariate analysis was used to determine the effects of certain clinical factors (age, sex, time to revision from previous hip operation and number of previous revisions) on outcome.

RESULTS: Patients reported disability both on hip-specific and general health measures. The time to revision from previous operation positively correlated with SF-36 mental component scores ($p = 0.003$), WOMAC function ($p = 0.04$) and WOMAC pain ($p = 0.03$). Age, gender and number of past revisions did not affect outcome.

CONCLUSIONS: Patients who undergo acetabular revision with a roof ring will continue to have some disability in the first 3 years after the procedure. A greater time between the previous operation and the revision operation is associated with a better outcome. Patients' expectations of postoperative results should be realistic in the face of a challenging reconstructive procedure.

OBJECTIF : Évaluer le rôle des prédicteurs possibles du résultat fonctionnel après une arthroplastie acétabulaire et évaluer les résultats de la révision effectuée au moyen d'un bouclier de renfort.

CONCEPTION : Étude de cas rétrospective.

CONTEXTE : Centre d'aiguillage de soins tertiaires.

PATIENTS : Vingt-quatre patients (âge moyen de 72,7 ans) qui avaient subi une révision acétabulaire au moyen d'un bouclier de renfort ont été suivis pendant 2,8 ans en moyenne.

INTERVENTIONS : On a procédé à une arthroplastie acétabulaire de révision en utilisant le bouclier de renfort de Mueller ou de Burch-Schneider, une greffe osseuse et une cupule en polyéthylène cimentée.

MESURES DE RÉSULTATS : Score modifié de Harris pour la hanche (mesure de l'amplitude du mouvement omise), questionnaire sur la santé SF-36 et résultat mesuré en fonction de l'indice Western Ontario McMaster (WOMAC) sur l'arthrose. On a utilisé une analyse à variables multiples pour déterminer les effets, sur le résultat, de certains facteurs cliniques (âge, sexe, période écoulée entre la révision et l'intervention précédente et nombre de révisions précédentes).

RÉSULTATS : Les patients ont déclaré une incapacité à la fois spécifique à la hanche et liée à leur état de santé général. On a établi un lien positif entre la période écoulée entre l'intervention précédente et la révision et les résultats du volet sur les éléments mentaux du questionnaire SF-36 ($p = 0,003$), la fonction

From the Division of Orthopaedic Surgery, Department of Surgery, St. Michael's Hospital, University of Toronto, Toronto, Ont.

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Correspondence to: Dr. Emil H. Schemitsch, Division of Orthopaedic Surgery, Department of Surgery, University of Toronto, Ste. 800, 55 Queen St E, Toronto ON M5C 1R6; fax: 416 359-1601

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selon l'indice WOMAC ($p = 0,04$) et la douleur selon l'indice WOMAC ($p = 0,03$). L'âge, le sexe et le nombre de révisions précédentes n'ont pas eu d'effet sur le résultat.

CONCLUSIONS : Les patients qui subissent une révision acétabulaire avec bouclier de renfort continueront d'avoir une certaine incapacité au cours des trois premières années suivant l'intervention. On établit un lien entre un meilleur résultat et la longueur de la période écoulée entre l'opération précédente et l'intervention de révision. Les patients devraient avoir des attentes réalistes à l'égard des résultats postopératoires face à une intervention de reconstruction difficile.

Revision of acetabular components in total hip arthroplasty is becoming an increasing problem. Even Charnley's low-friction arthroplasty had a 10% revision rate by 20 years.¹ Others have reported similar rates.^{2,3} One study found that late aseptic loosening was the major reason for revision hip arthroplasty in the survival of cemented polyethylene acetabular components beyond 10 years,⁴ at which time, there was a 2% probability for acetabular revision.⁴ By 16 years, this probability increased to 16%.⁴ The use of metal-backed components in young patients did not decrease the revision rate.⁴ As the population's life expectancy increases, leading to more hip arthroplasties, greater numbers of patients will have aseptic loosening of the prosthesis and require acetabular revision.

In some cases, revision of the acetabular component may be complicated by deficient bone stock caused by any of the following: the original osteoarthritic process with cystic degeneration of subchondral bone; reaming at the time of the primary procedure; upward migration of the acetabular component over time as aseptic loosening occurs; and osteolysis secondary to wear debris.^{5,6} The medial wall of the acetabulum tends to become deficient as a result of wear or loosening.⁷ Several methods have been devised that address acetabular bone loss, including resection arthroplasty, cement augmentation, allografting, oversized cementless components, bipolar arthroplasty, roof reinforcement rings, and combinations of these methods.⁸⁻¹⁴ The use of reinforcement rings is relatively un-

common in acetabular revision, being reserved for cases of severe bone-stock deficiency. Most studies involving revision acetabular arthroplasty have examined radiographic results and survival of the components^{2,4,15,16} as well as functional hip scores. Few have used health-related quality of life questionnaires as means of assessing outcome. Moreover, some studies have not described the outcome of revision hip arthroplasty directly; rather, they have examined the rate of revision of primary hip arthroplasty.

The purpose of this study was to evaluate the role of potential predictors of functional outcome, using both disease-specific and generic measures of health, and to describe the outcome of revision acetabular arthroplasty in cases of more severe bone-stock loss necessitating the use of a roof reinforcement ring. The results of this study may be valuable for prognostic purposes and provide benchmark data for functional outcomes.

PATIENTS AND METHODS

We reviewed the charts of consecutive patients who had undergone acetabular revision with a roof reinforcement ring after failure of total hip arthroplasty at the authors' institution between 1987 and 1996. The following information was obtained: date of birth, gender, diagnosis of hip disease, date of primary hip arthroplasty and operative details (reason for revision, date of operation, surgical approach, operative time, results of intraoperative cultures, acetabular deficiency, use and type of bone graft, acetabular roof reinforcement ring, acetabular compo-

nent, cement use, use of screws to stabilize the roof ring). The immediate postoperative course and complications were noted. Twenty-four of 34 patients (70.6%) eligible for the study responded and agreed to participate.

Patients were excluded from the study for either of the following reasons: infected hip arthroplasty or reconstruction after Girdlestone arthroplasty. Patients who had undergone conversion of a hemiarthroplasty to a total hip arthroplasty were not included.

All except 1 of the revisions were performed by the senior author (J.P.W.) through a posterior approach to the hip. The 1 exception was done by a colleague at the same institution through a lateral approach. Before revision, the possibility of infection had been investigated by measuring the erythrocyte sedimentation rate (ESR) and by hip aspiration. The ESR is a nonspecific indicator of inflammation and infection. C-reactive protein was not routinely available. Intraoperative cultures of tissue obtained on all patients gave negative results. The femoral component was revised simultaneously in 6 patients. A roof reinforcement ring¹⁷ with a morcellized femoral head allograft was used to manage severe acetabular bone-stock deficiency. Structural allografting was not required in any case. The acetabular bone loss was such that a large cementless cup would provide insufficient contact with host bone. The majority of acetabular defects were large cavitary medial and superior deficiencies, and Mueller rings were used in 22 patients. In 2 patients, Burch-Schneider rings were used. Eight patients had undergone 1 revi-

sion of the original arthroplasty before implantation of the reinforcement ring, and 1 patient had undergone 4 revisions. The other 15 patients had not undergone any revision of their arthroplasty.

To evaluate functional outcome, the following questionnaires were administered to patients: a modified Harris hip score (excluding range-of-motion and deformity portions),^{18,19} the SF-36 health survey²⁰ and its 2 summary measures — PCS (physical component score) and MCS (mental component score) — and the Western Ontario McMaster (WOMAC) osteoarthritis index.²¹ The WOMAC index has been used previously to assess the results of primary hip arthroplasty.¹⁸ Since the purpose of this investigation was to evaluate the patients' perception of functional status, we used a modified Harris hip score. A previous study has shown that the range-of-motion portion of the Harris hip score correlates with the WOMAC function score.²² The maximum score achievable on this modified Harris hip score was 90 points, indicating the most positive functional status.

To determine the effects of certain clinical factors on outcome, multivariate analysis was used. Potential predictors of functional outcome were age, gender, time to revision from previous hip operation, and the number of previous revisions.

STATISTICAL ANALYSIS

A correlation analysis was performed by generating Pearson correlation coefficients between the independent variables. None of the potential predictor variables were found to be significantly correlated with each other (Pearson correlation coefficients less than 0.80). Age and diagnosis were the only pair of predictor variables that approached significant correlations, but their Pearson correlation coefficient was -0.67 (*p* = 0.0001).

Therefore, these 2 factors were considered separately for the multivariate analysis. Bivariate analysis was performed between the 5 outcome measures (SF-36 PCS, SF-36 MCS, WOMAC pain score, WOMAC stiffness score and WOMAC function score) and the potential predictors of functional outcome. Potential predictor variables were considered to be significant if their *p* values were less than 0.15.²³ Multivariate analysis was then performed.^{23,24} First, the data were tested for normality by generating normal probability plots of the residuals and calculating the Shapiro-Wilk statistic. Second, multicollinearity was checked by examining the variance inflation factor. Third, pairwise interactions between the potential predictor variables were examined and entered into the regression model if present. Fourth, stepwise linear regression was carried out and partial *R*² values were generated. Those variables meeting the *p* = 0.15 significance criteria were used in the final regression model, and parameter estimates with 95% confidence intervals were determined. By examining the parameter estimate, the relationship between the outcome variable and the predictor variable can be determined. That is, one can predict the change in the outcome based on the change in the predictor variable if the parameter estimate is known.

All calculations were performed using SAS software (Statistical Analysis System, Version 5, Cary, NC) on a MAG1450 personal computer (Magnum Inc., Markham, Ont.).

RESULTS

Demographic results

Of 34 patients sent questionnaires, 24 agreed to participate. Eight patients did not respond despite follow-up reminders by telephone and letter; 1 had died and 1 did not complete the ques-

tionnaire because of a recent death in the family. There were no differences in the demographic characteristics between the responders and the non-responders (Table I). Seventy-five percent of the patients were female. The predominant initial diagnosis ne-

Table I

Patient Demographic Data for 24 Patients Who Had Acetabular Revision With a Roof Ring

Demographic	No. of hips
Patient gender	
Male	6
Female	18
Patient age, yr*	72.7 (6.4)
Diagnosis	
Osteoarthritis	18
Nonosteoarthritis	2
Unknown	4
Reason for revision	
Dislocation	2
Aseptic loosening	21
Acetabular fracture	1
Time to revision, yr*	9.3 (5.6)
Follow-up, yr*	2.8 (1.7)
Duration of symptoms, mo*	19.1 (21.3)
Operative time, min*	115.2 (43.5)
Estimated blood loss, mL*	650.0 (302.3)
Working status	
Working	1
Working part time due to hip	1
Not working due to hip	2
Not working for other reasons	12
Retired	7
Unknown	1
General satisfaction	
Extremely satisfied	2
Very satisfied	9
Moderately satisfied	1
Mildly satisfied	5
Not at all	7
Complications	
Dislocation	4
Deep venous thrombosis	2
Heterotopic ossification	1
Hematoma	3
Loosening	1

*Values are means (and standard deviations).

cessitating hip arthroplasty was osteoarthritis. The most common reason for revision was aseptic loosening. The average time to revision from the previous surgery was 9.3 years (Table I).

Analysis of predictors of outcome

Bivariate analysis of the potential predictors of outcome and the clinical outcome scoring systems of the SF-36 and WOMAC osteoarthritis index

found that the time to revision from the previous operation was the only significant factor and multivariate analysis confirmed this. Age, gender and the number of previous revisions did not influence outcome (Table II). A greater time interval between the current revision and the previous hip surgery led to better outcomes (Table II), as indicated by the positive parameter estimate. The PCS of the SF-36 health survey and the WOMAC stiff-

ness score were not influenced by any of the potential predictors of outcome.

Outcome measures

Harris hip score

The mean (and standard deviation) modified Harris hip score was 44.2 (23.3) points, well below the maximum of 90 points attainable in this study.

SF-36 scores

The SF-36 scores were generally lower than those of the normal American population across the dimensions of physical function ($p = 0.00005$), role physical ($p = 0.00005$), bodily pain ($p = 0.00005$), general health ($p = 0.0004$), vitality ($p = 0.00005$), social function ($p = 0.00005$) and role emotional ($p = 0.02$) (Fig. 1). However, mental health scores were similar to norms ($p = 0.05$). The PCS and MCS were below age-adjusted norms ($p = 0.00001$ and $p = 0.01$, respectively) (Fig. 2).

WOMAC scores

In the categories of pain, stiffness, and function, WOMAC index scores were only about two-thirds of the maximum values attainable (Fig. 3).

Complications

Overall, about 46% of patients experienced a postoperative complication, mostly in the early postoperative period (Table I). The overall reoperation rate was 12.5% (3 of 24 patients). Of the 4 dislocations, 2 were managed with closed reduction, 1 with open reduction and 1 with revision of the reinforcement ring. Femoral head size was not important in predicting dislocation. One of the patients with a dislocation who was successfully treated with a closed reduction also had had a concurrent femoral revision. This pa-

Table II

Multivariate Analysis of Clinical Predictors on Outcome of Acetabular Revision With a Roof Ring

Analysis measures	SF-36 MCS	WOMAC pain	WOMAC function
Significant factors*	Time to revision	Time to revision	Time to revision
R ²	0.57	0.61	0.41
p value	0.003	0.03	0.04
Intercept	35.2	26.8	29.5
Parameter estimate (95% CI)	1.3 (0.5 to 2.1)	3.1 (1.3 to 4.9)	0.03 (-0.67 to 0.73)

*There were no significant factors for SF-36 physical component score and WOMAC (western Ontario MacMaster University osteoarthritis index) stiffness. CI = confidence interval, MCS = mental component score.

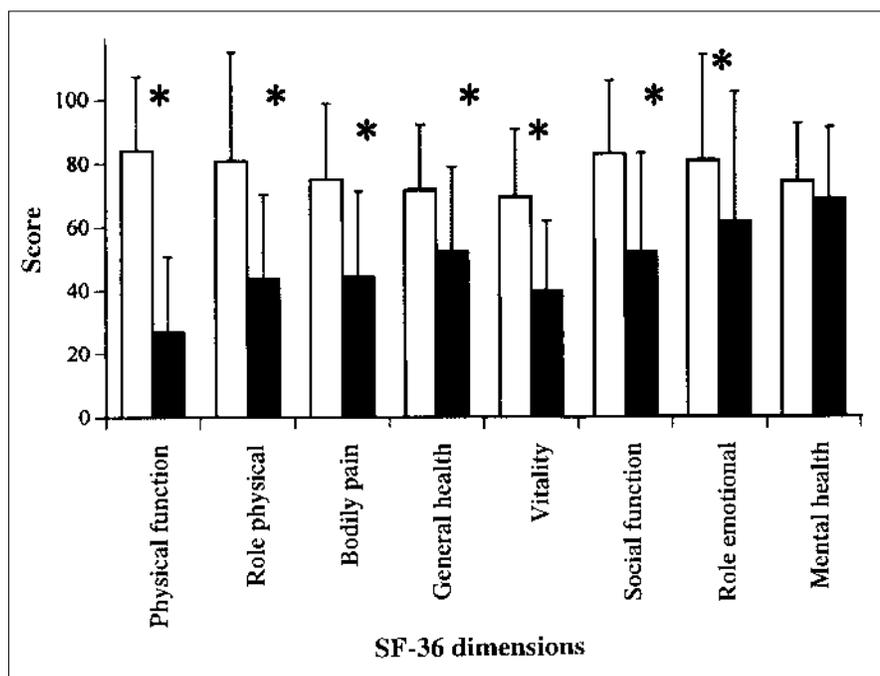


FIG. 1. Postoperative SF-36 health survey scores were generally lower in patients who had acetabular reconstruction with a roof ring (black bars) than in the normal population (white bars) except in the category of mental health. *Significant at $p = 0.05$.

tient was also one of those who had suffered a deep venous thrombosis. None of the other patients who had undergone femoral revision simultaneously had any complications noted. One patient who had a Burch-Schneider ring implanted suffered component loosening. Approximately 1 month postoperatively another Burch-Schneider ring was implanted. There were no other cases of acetabular component loosening.

DISCUSSION

This study showed that the only significant variable affecting outcome was the time to revision from the previous operation. A greater time lapse from the previous procedure was associated with a better outcome. It may be that patients were doing relatively well for years and then deteriorated as osteolysis developed. The average duration of symptoms in this study was 19.1 months, and 9.3 years was the average time elapsed between the current revision and the previous operation. Patients who had earlier revisions in relation to the previous operation generally had worse outcomes. These patients may not have had a good result from the original total hip arthroplasty for several reasons, including the quality of the soft tissue and bone, and for technical reasons. It must be emphasized that this is a retrospective study and that no preoperative functional data are available. Age, gender and the number of previous revisions did not affect clinical outcomes. Other factors must be involved to explain the outcome, since the variable of time from the previous operation accounted for only a portion of the variation in clinical outcomes.

Patients reported disability on both hip-specific and generic clinical outcome measures after revision acetabular arthroplasty with roof reinforcement rings, as measured by a modified Harris hip score, WOMAC index and SF-

36 scores. Although no preoperative data are available, this investigation provides benchmark values for these functional outcome measures after revision acetabular arthroplasty with roof reinforcement rings. Self-reported patient outcome measures are increasingly being reported in the orthopaedic literature as a standard objective means of comparing results among investigators. (In the revision arthroplasty literature, few studies are available that have used patient-oriented outcome scales for reporting results.)

Stockl and colleagues²⁵ relied on radiographic findings to describe the outcome after revision with a Mueller reinforcement ring. Garbuz and associates²⁶ showed that roof reinforcement rings contributed to a successful outcome in 7 out of 8 hips, with the allograft uniting to the host bone. The patients in this study had been assessed pre- and postoperatively by the Harris hip score and radiographically. Success was also defined as no need for further surgery. Comparison with another study,²⁷ which had a 2.5-year follow-up, found improved outcomes with the Mueller roof reinforcement ring and no differences in outcome compared with primary hip arthroplasty. These authors felt that deficient acetabula could be successfully reconstructed with the use of a roof reinforcement ring. The results of our study are less optimistic with respect to the functional outcome of acetabular reconstruction with roof rings. This may be attributed to the use of patient-defined functional outcome measures.

The incidence of complications was 46% in this series. This rate seems relatively high but would be expected in revision hip surgery. Other studies have reported significant complications postoperatively.^{11,27,28} The procedures are technically demanding, and reoperation through scar tissue makes the revision challenging.

The strengths of this study in-

cluded the use of patient-oriented measures of health. Both generic and disease-specific scales were administered. The WOMAC osteoarthritis index has not been used frequently for revision hip arthroplasty, but it serves as a useful index for patients with hip problems. Although the follow-up was 2.8 years, this study provides useful information for patients. Whereas long-term results are important (especially since postoperative recovery from revision arthroplasty may take longer than from primary hip arthroplasty), early outcomes are of value to

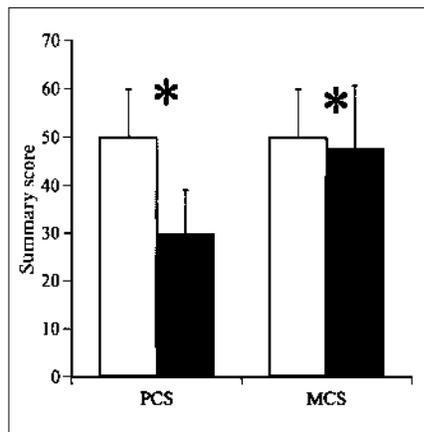


FIG. 2. Summary of physical component score (PCS) and mental component score (MCS) from the SF-36 health survey for patients who had acetabular reconstruction with a roof ring (black bars) and for the normal population (white bars). *Significant at $p = 0.05$.

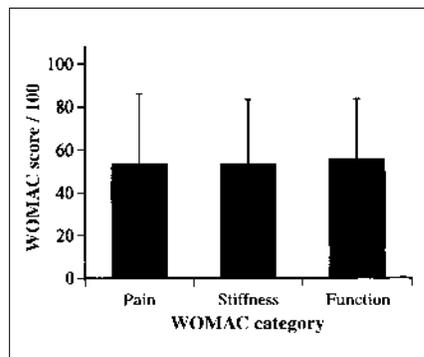


FIG. 3. Postoperative scores of the Western Ontario McMaster (WOMAC) osteoarthritis index for patients who had acetabular reconstruction with a roof ring.

patients about to undergo major surgical procedures. Patients often would like to know what their status may be in the first few years after surgery and to see if there is any short-term gain. Even though no preoperative data were available owing to the retrospective nature of this investigation, the absolute values of the joint-specific and generic indices of health and comparison with normative data still provide prognostic information. Moreover, our study provides results for functional outcome scores in revision arthroplasty with reinforcement rings that can be used as comparison points for future studies. The value of this study may be that it provides at least some preliminary information on functional outcomes in a group of patients that has not been well studied. Patients who undergo acetabular revision requiring roof reinforcement rings should be cautioned that although surgery will be beneficial, the outcome to be expected will not achieve even close to normal hip function. Also, a relatively high rate of complications can be anticipated with revision acetabular surgery.

CONCLUSIONS

Patients who require a revision of a total hip arthroplasty with implantation of a roof reinforcement ring will likely not achieve normal physical function in the first 3 years after operation. About 46% will experience some complication, which is consistent with the findings of previous studies. A greater time between the previous operation and the revision operation is associated with a better outcome. Patients' expectations of postoperative results should be realistic in the face of a challenging reconstructive procedure. Future studies should examine the role of other variables, such as psychosocial factors, in explaining the variation seen in outcomes. Prospective studies would be

useful to determine the degree of clinical change from preoperative function and its impact on the perception of self-reported disability. As further investigations are conducted on patients who have undergone complex reconstructive revision hip arthroplasty procedures, patient-oriented outcome measures will continue to play an important role, especially when comparing the results of different investigators.

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Notices

Avis

American Society for Surgery of the Hand conference and courses

The American Society for Surgery of the Hand will hold its 2000 annual meeting "Overcoming Adversity: Hand Surgeons Shaping the 21st Century" from Oct. 5 to 7, 2000, in Seattle, Wash. For further information contact the American Society for Surgery of the Hand, Suite 600, 6300 North River Rd., Rosemont IL 60018-4256; tel 874 384-8300, fax 847 384-1435, www.hand-surg.org

ACS clinical congress

The 2000 clinical congress of the American College of Surgeons will be held in Chicago from Oct. 22 to 27, 2000. The program includes 33 post-graduate courses, more than 350 hours of general and specialty sessions, more than 300 research-in-progress papers, a series of press conferences

and approximately 175 scientific exhibits. For further information contact the American College of Surgeons at 633 North Saint Clair St., Chicago IL 60611-3211; tel 312 202-5000, fax 312 202-5001, www.facs.org

Techniques in advanced laparoscopic and gynecologic surgery

The Mayo Clinic Scottsdale is sponsoring the 13th annual course "Techniques in Advanced Laparoscopic and Gynecologic Surgery." It will be held from Nov. 1 to 4, 2000, at the Grand Wailea Resort, Wailea, Hawaii (www.grandwailea.com). Course director is Dr. Javier F. Magrina. Credit: AMA Category I and ACOG (to be decided). Fees are US\$670. Contact: Sarah Dorste, CME Department, Mayo Clinic Scottsdale, 13400 East Shea Blvd., Scottsdale AZ 85259; tel 480 301-4661, fax 480

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Peer review in biomedical publication — call for abstracts

The fourth international congress on peer review in biomedical publication will be held from Sept. 14 to 16, 2001, at the Princess Sofia Inter-Continental Hotel in Barcelona, Spain. The *Journal of the American Medical Association* and the *British Medical Journal* invite abstracts on any aspect of editorial peer review, scientific publication and the dissemination of scientific information. Abstracts that summarize new research and findings will be given priority. The deadline for abstracts is Jan. 15, 2001. For information on preparing and submitting abstracts contact Annette Flanagan, JAMA, 515 North State St., Chicago IL 60610, USA; tel 312 464-2432, fax 312 464-5824, jama-peer@ama-assn.org■

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