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Postoperative Irradiation for Prevention of Heterotopic Bone Formation after Total Hip Replacement Arthroplasty

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Heterotopic bone formation is a complication which occurs in 0.6 to 61.7% of patients after total hip replacement arthroplasty. We reviewed 4 patients (8 hips) who received postoperative irradiation on their hips for prevention of heterotopic bone formation in the Department of Therapeutic Radiology, Seoul National University Hospital from January 1981 through August 1985. Radiation therapy was started 6 to 10 days postoperatively with the dosage of 2,000 cGy given in 10 fractions. As a result, 7 hips had Grade 0 and 1 hip had Grade 1 heterotopic ossification according to modified Brooker system. Our result and review of the literatures strongly support that the postoperative radiotherapy is effective for prevention of heterotopic bone formation in high risk group.

Key words: Total hip replacement arthroplasty, Heterotopic bone formation, Postoperative irradiation.

INTRODUCTION

Total hip replacement arthroplasty (THRA) is an effective method of getting rid of pain and improving function of hip with few major complications related to the surgery[1, 2, 3]. The reported incidence of heterotopic bone formation after THRA ranges widely from 0.6 to 61.7 percent regardless of diagnosis in each series [4, 5, 6, 11], and it causes a significant functional impairment in up to 28% of those with radio-graphically visible bone in the soft tissues. Bone islands are formed in the soft tissue planes around hip joint where there is an abundance of fibrous tissue and muscle: when bone formation is fully developed, it may completely obliterate the joint space compromising otherwise satisfactory surgical result. This has led to search for a method of preventing heterotopic bone formation. Some reports[12, 13] have demonstrated the efficacy of postoperative irradiation of the hip after THRA for prevention of heterotopic ossification. This paper is on our clinical experience with postoperative irradiation for pevention of heterotopic bone production.

MATERIALS AND METHODS

Between January, 1981 and August, 1985, five patients, nine hips, received postoperative irradiation after THRA, in the Department of Therapeutic Radiology, Seoul National University Hospital. One patient (one hip) was excluded from this study because irradiation was discontinued after two treatments and the patient was lost to follow-up. This report is based on the four patients with eight hips involved. All the patients were male adults with preoperative diagnosis of ankylosing spondylitis. After operation, the patients were seen in the Department of Therapeutic Radiology as soon as they were considered fit enough to attend. Radiation therapy started 6 to 10 days postoperatively (mean 7.9 days). Midplane dose of 2,000cGy was given in 10 fractions in 2 weeks via AP and PA

parallel opposed port, with Co-60 teletherapy unit (Fig. 1). Each field was treated daily 5 days per week. Response to the treatment was assessed by postoperative hip X-rays taken 8 weeks after surgery, since the heterotopic ossification matures in 8 weeks after the hip surgery[6, 12, 13]. A modified Brooker grading system[14] (Table 1) was used to evaluate the response.

RESULTS

A total of 8 hips were irradiated and 7 (87.5%) of them had no evidence of heterotopic bone formation (Grade 0) and 1 (12.5%) had islands of bone within the soft tissues around the hip (Grade I). There was no single case of more advanced bone formation (Grade II or more) (Table 2, Fig. 2, 3). Complications directly attributable to radiation therapy was not observed. There was no clinical evidence of delayed wound-healing. The patients experienced no symptoms attributable to radiation therapy.

DISCUSSION

Ectopic ossification, a roentgenographically

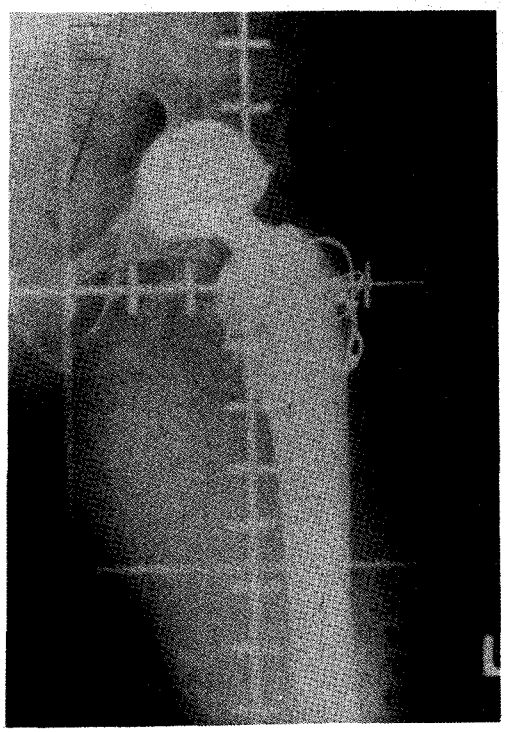

Fig. 1. Outline of a typical radiation treatment field.

Table 1. Modified Brooker Classification of Heterotopic Ossification

Grade	
0	No bone islands visible.
I	Islands of bone within the soft tissues about the hip.
II	Bone spurs from the pelvis or proximal end of the femur leaving at least 1 cm between opposing surfaces
III	Bone spurs from the pelvis or proximal end of the femur reducing the space between opposing bone surfaces to less than 1 cm.
IV	Apparent bone ankylosis of the hip

Table 2. Results

Patient No.	Sex/Age	Side	RT dose (cGy)	Interval Op—RT (days)	Grade
1	M/27	R	2000 cGy	8 days	0
		L	2000	8	1
2	M/36	R	1800	10	0
		L	1800	7	0
3	M/37	R	2000	7	0
		L	2000	10	0
4	M/44	R	2000	6	0
		L	2000	7	0

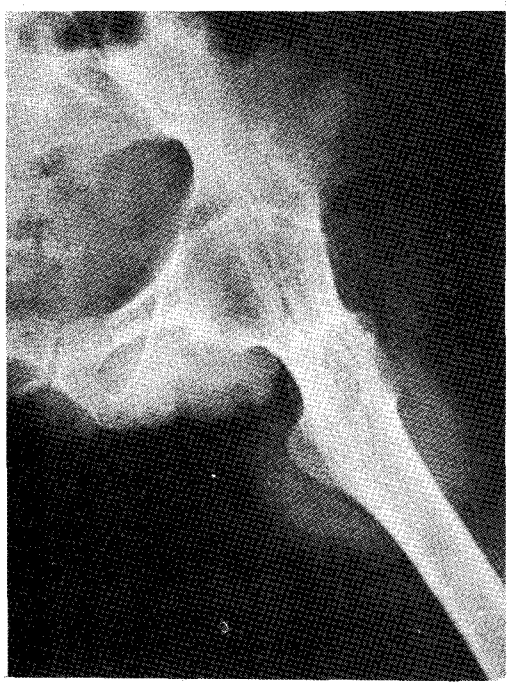

Fig. 2. Pre-operation x-ray shows a marked ankylosed hip.

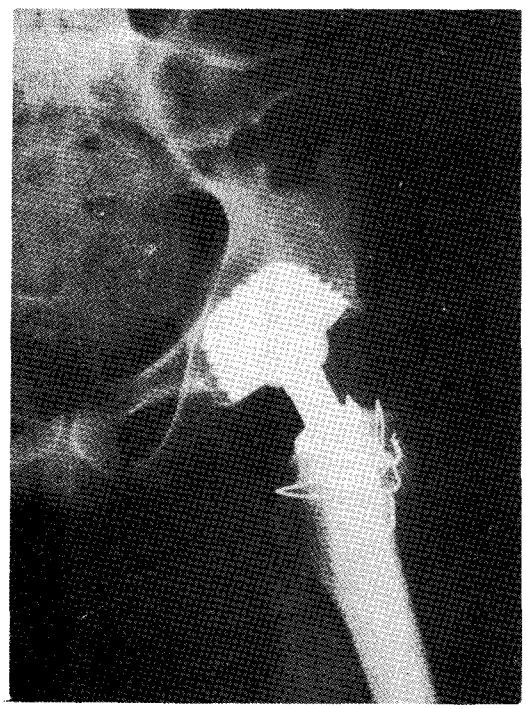

Fig. 3. Post-operation and radiation x-ray shows no evidence of ectopic bone formation (Grade 0).

dignosed sequelae after the surgical procedures on the hip, originally was considered to be the cause of pain and failure after THRA. According to Charnley,[1] however, it is not associated with pain after THRA, but it causes a reduction in range of motion after the hip replacement. Etiology or mechanism of heterotopic bone formation after surgery is not clear, but role of surgical trauma, bone dust left in surgical field and hematoma formation around hip joint have been speculated.[9]

Surgeons have attempted to prevent the heterotopic bone formation by careful irrigation of the operative site with sterile saline, gentle handling of the tissues, and also by minimizing hemorrhage or infection. However, heterotopic ossification still occurred. Ratter et al[8] insisted that the development of ectopic ossification is not just a problem of surgical technique.

Some association of the male sex, limited range of motion, previous ectopic bone, degenerative arthritis, bilateral hip disease, and infection with the development of postoperative bone formation after total hip replacements was also noted[15, 19]. Bilaterality seemed to have the greatest effect on the development of ectopic bone formation, but the association was more likely due to the high incidence of massive osteophytic osteoarthritis in patients with bilateral involvement[8, 13].

Bisla et al found the highest incidence (61.7%) of ectopic bone formation in patients with ankylosing spondylitis[5]. This was considered due to change of local environment around the joint after surgery and thereby accentuation of the osteoblastic activity leading to the excess ossification[20].

While our understanding of the pathogenesis of ectopic bone formation is incomplete, certain observations have been made in animal model system which shed some light upon why irradiation of the tissue bed is helpful in preventing the ectopic ossification[13]: 1) Osteogenesis may result from the bone fragments shed into the wound during surgery, 2) it may be a result of the migration and differentiation of a blood component with innate osteogenic potential or 3) the result of migration and differentiation of cells from the epimysium, perimysium and endomysium.

Craven et al[21] implanted demineralized long bone diaphysis of adult rat into abdominal pouches and irradiated with orthovoltage X-rays at various time intervals after implantation with graded doses. They found that cells were most vulnerable to radiation injury during the period of migration of the so-called amoeboid mesenchymal cells derived

from muscular connective tissues and that muscle mesenchymal cells and not blood vascular elements were the ancestors of osteoprogenitor cells, although the possibility of bloodborne cells entering the system later could not be excluded. In their system, bone morphogenesis was always completely suppressed if radiation were given during the first 4 days after implantation of demineralized bone matrix.

Coventry et al[12] observed that, in hips with massive ectopic bone formation following previous surgery on the hip, irradiation was most successful in preventing ectopic ossification if administered within the average of 6.5 days following excision of heterotopic bone. MacLennan et al[13] reported that all patients commencing radiotherapy within 5 days of the removal of heterotopic bone achieved a satisfactory result. Therefore, according to the above and our experience, the earlier the radiation therapy is begun after the surgery, the more effective it is.

Neuhauser et al[22] studied the effect of radiation on the growing vertebrae of children whose spines were encompassed in radiation fields, mainly for abdominal malignant disease, relating this effect to dosage and age and found that with doses of more than 2,000 cGy, severe changes in bone contour and complete arrest of cartilage growth occurred, especially in very young patients. Bonarigo et al[23] designed a series of experiments to show the effects of tumor on callus formation and simulated that tumor and radiation each had a detrimental effect on callus formation. These authors suggested that since chondrogenesis was more sensitive to radiation than osteogenesis, their observations of fracture non-union after irradiation indicated that radiation inhibited endochondral bone formation in bridging cells. Two thousand cGy was enough to prevent chondrogenesis. Since ectopic bone production and callus formation might involve progenitor cells with similar radiosensitivity, the dose of 2,000 cGy seemed to be reasonable, and had been accepted as a usual dose. We also obtained good results with 2,000cGy. Recently Anthony et al[24] reported that 1,000cGy given in 5 fractions is apparently as effective as 2,000cGy in 10 fractions in high risk patients. However, more specific study is needed on this issue.

Potential carcinogenic effect of radiation was of equal concern when selecting an effective dose level. Kim et al[25] found no instance of radiation induced soft tissue sarcoma in twenty patients who were treated with less than 1,400rets (2,000 cGy in 10 fractions equals 875 rets) and no radiation-induced bone sarcoma in thirteen patients who were treated with less than 1,100 rets. They found that the median latency period was 11 years for the induction of bone sarcomas and 12years for the induction of soft tissue sarcomas which occurred in patients who received high dose. In addition, Brady[26] could find no report of radiation induced sarcoma at doses below 3,000cGy in three weeks. Our patients have not been followed up long enough to observe the potential carcinogenic effects expressed fully, but no cases of subsequent cancer in irradiated area have been observed thus far in our patients. Although the remote chance of late malignant disease never can be entirely eliminated until many years pass by, it appears that carcinogenesis is an unlikely side effect.

While this study of the use of radiation therapy was in progress, diphosphonate (EHDP) came into experimental use and have been shown to decrease the calcification of callus suggesting a possible role in the therapy of heterotopic bone formation. But, since recalcification of callus occurs after cessation of diphosphonate therapy[27], it cannot be used as the sole treatment for heterotopic bone formation. It may be suggested that in some patients with very high risk of heterotopic bone formation diphosphonates and radiation therapy might be used. Indomethacin was found to decrease the incidence of ectopic bone formation if given after operation[28], but a very high percentage (35-50%) of patients receiving usual therapeutic doses of indomethacin experience untoward symptoms, and about 20% must discontinue its use. Also steroid was used as a prophylactic measure. But more specific study is required for the use of drug for prevention of heterotopic bone formation.

CONCLUSIONS

We have reviewed 4 patients (8 hips) who recieved postoperative hip irradiation for prevention of heterotopic bone formation after total hip replacement arthroplasty. Our study and review of literatures support that the postoperative hip irradiation is effective for prevention of heterotopic bone formation. Early commencement of irradiation is important and the dosage of 2,000cGy in 10 fractions is considered adequate.

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=국문초록=

고관절전치환 성형술후 관절주위 골형성 예방을 위한 수술후 방사선 요법

서울대학교 의과대학 치료방사선과학교실

박우윤 · 김일한 · 하성환 · 박찬일

관절주위 골형성은 고관절치환 성형술을 시행받은 환자의 0.6~61.7%에서 생길 수 있는 합병증이다.

저자들은 1981년 1월부터 1985년 8월까지 서울대학교병원 치료방사선과에서 고관절전치환 성형술후 관절주위 골형성 예방을 위하여 방사선요법을 시행받은 4명의 환자(8개의 고관절)를 분석하였다.

방사선요법은 수술후 6~10일이내 시작하였으며 2,000 cGy 를 10회 분할조사하였다. Modified Brooker system에 의하여 7개의 고관절에서는 Grade(1개 의고관절에서는 Grade) 2의 결과를 얻었다. 저자들의 이번 연구결과 및 문헌조사에 의하면 고관절 성형술후 관절주위 골형성 예방을 위하여 호발군에 있어서의 방사선요법은 효과적이라고 하겠다.