Original Research Article

The Second Hip Fracture is not an Independent Predictor of Poor Outcomes in Elderly Patients – A Case-Control Study

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Abstract

Introduction: Hip fracture is particularly seen in elderly patients with frailty and osteoporosis and leads to diminished functional independence and quality of life. Despite the susceptibility of these patients to a second hip fracture (SHF), the literature insufficiently discussed its impact leading to poor outcomes. This study aims to directly assess the outcomes of elderly patients with initial hip fractures (IHF) vs those experiencing an SHF within a well-matched group with similar characteristics. **Materials and Methods:** This case–control study gathered data from the clinical hip fracture registry at a medical center from 2019 to 2022. Patients with SHF were matched with those with IHF in a 1:2 ratio according to the similarity of age, sex, and Charlson Comorbidity Index classification. Demographics at admission, baseline characteristics, and 1-year postoperative outcome were compared between the SHF and IHF groups. **Results:** Thirty-two SHF patients were matched with 64 IHF patients (81.25% of women, median age of 86 years). Anthropometric measurements and socioeconomic factors were not significantly different between the two groups. No differences in baseline characteristics were observed, except IHF patients had a significantly lower T-score than SHF patients (−3.98 vs. −3.31, $P = 0.016$). At one-year follow-up, despite a notable decrease in Barthel Index scores and an uptick in EQ-5D measures among the patients, the IHF and SHF groups demonstrated similar quality of life and a high level of activities of daily living. **Discussions:** In this case-control study, after matching for age, sex, and comorbidities, an SHF did not indicate poorer outcomes than an IHF, providing a more optimistic outlook for the patients and healthcare providers. **Conclusion:** Despite the significant challenges presented by hip fracture, the one-year postoperative outcomes did not differ between IHF and SHF patients, suggesting that SHF is not an independent predictor of poor outcomes following hip fracture in the elderly population.

Keywords

initial hip fracture, second hip fracture, predictor, outcome, quality of life

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Introduction

Hip fracture is well established to be a severe condition, leading to impaired functional independence and decreased quality of life (QoL).[1-4] The number of hip fractures was predicted to increase to over 6 million by 2050 worldwide, which would pose a massive burden on the healthcare system and economies worldwide.[5] After experiencing the initial fracture, individuals with osteoporosis or frailty are at a heightened risk of sustaining a second hip fracture (SHF).[6,7] Although the negative impact of hip fracture has been clearly investigated in previous studies, the impact of SHF remains discrepant and is not fully understood.[8]

In recent years, there has been a growing focus in published papers on determining the risk of SHF and their associated mortality risks[1,9-12] or evaluating outcomes following SHF.[13-16] Pearse et al.[17] initially reported that SHFs significantly impacted patients' mobility and social independence compared to patients with initial hip fractures (IHF). In another study conducted by Sawalha et al.[16], involving 5341 patients with IHF and 633 patients with SHF, significant differences were noted between the two groups in terms of age, gender, mental status, American Society of Anesthesiologists (ASA) grading, and mobility score. Despite these disparities, the outcomes for both groups were comparable one year after the hip fractures. On the other hand, comorbidity was reported to be a significant predictor influencing rehabilitation after hip fracture, with a higher Charlson Comorbidity Index (CCI) associated with unfavorable rehabilitation results.[18-20] Considering that patients with SHF tend to be older, more frailty, and have more comorbidities, all of which are risk factors for poor outcomes, there is still a conflicting perspective on whether SHF independently impacts outcomes for geriatric patients after a hip fracture.

To investigate the impact of SHF on the elderly, accounting for potential interference from other confounding factors, a matched-pair case-control study was designed. We hypothesized that, given the shared characteristics of age, sex, and comorbidities between the two groups of patients experiencing SHF and those with IHF, their postoperative outcomes would be similar.

Materials and Methods

This is a retrospective matched-pair case-control study conducted using data retrieved from the clinical hip fracture registry at a medical center in Taipei, Taiwan. The inclusion criteria for patient enrollment involved individuals aged 60 years or older who sustained hip fractures and underwent surgical treatment. Patients were excluded if they underwent hip surgery for conditions other than primary hip fractures, such as osteoarthritis, trauma, tumor metastasis, infection, or avascular necrosis of the femoral head. The entire protocol and all instruments used were approved by the Ethical Committee of Taipei Medical University. All participants provided written informed consent for their participation and the publication of this study.

Study Design

From January 2019 to January 2022, 500 patients treated for hip fractures were identified from the clinical hip fracture registry. To clarify the data for further analysis, we excluded 58 patients from this cohort, who unfortunately passed away within one year. Among the remaining 442 patients, 32 experienced an SHF, while 410 patients suffered an IHF. We performed a matched-pair analysis at a 1:2 ratio, according to the homogeneity of age, sex, and comorbidity conditions through the Charles Comorbidity Index (CCI),[21] which was classified into normal (CCI 0), mild (CCI 1-2), moderate (CCI 2-4), and severe (CCI $\geq$ 5), to finally identify a control group of 64 patients from 410 patients with IHF. The study flowchart is demonstrated in Figure 1.

Demographic information was retrieved, including age at the time of hip fracture, sex distribution, height, weight, body mass index, social-economical factors (education, marriage status, coliving, caregiver, and occupation), types of fracture (femoral neck, trochanteric, and subtrochanteric fractures). Baseline characteristics at admission included mental status evaluation using the Short Portable Mental Status Questionnaire (SPMSQ), laboratory results (routine blood test and biochemical blood test), CCI, handgrip strength, bone mineral density measured by T-score recorded through Dual-Energy X-ray Absorptiometry (DXA).

All our patients were enrolled in a fracture liaison service to promote functional recovery.[22] Depending on their fracture patterns and conditions, they underwent hip arthroplasty or osteosynthesis. After surgery, they were provided with a comprehensive and tailored rehabilitation program aimed at maximizing their recovery and functional outcomes. Following their discharge from the hospital, patients were further managed with a multifaceted approach to address their underlying osteoporosis, according to their DXA results. This involved the implementation of anti-osteoporosis medications (AOMs) with calcium and vitamin D. Clinical outcomes were collected during the one-year follow-up, including QoL assessed through the EuroQol-5D questionnaire (EQ-5D), and activities

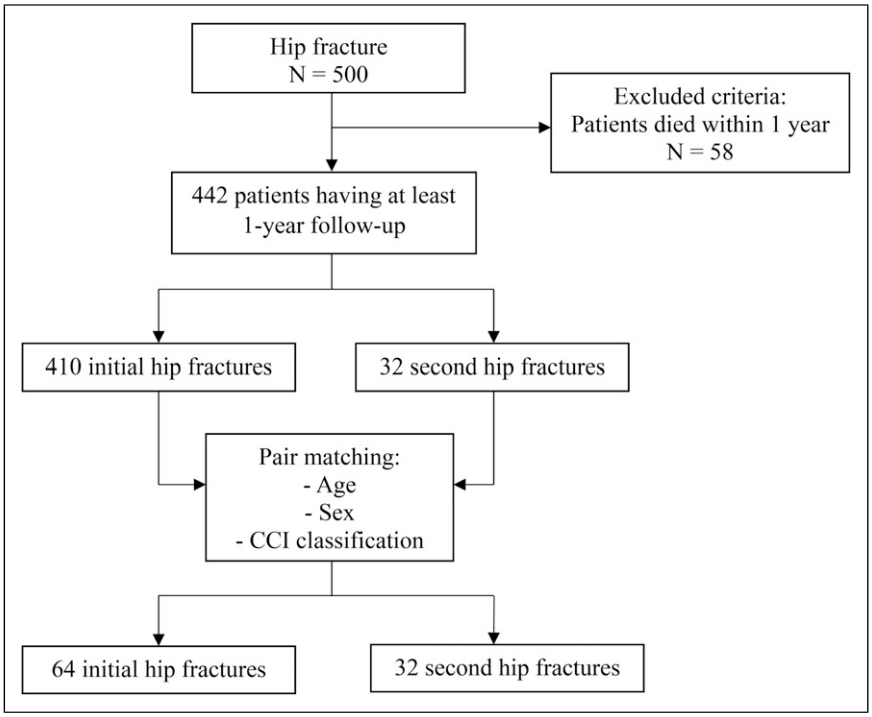

Figure 1. The study flowchart.

of daily living (ADL) evaluated using the Barthel Index (BI).

Instruments

The EQ-5D is a globally recognized tool for assessing health-related QoL.[23] This tool comprises five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression). For every dimension, there are three levels of severity (no problems, some problems, and significant problems). The EQ-5D was useful for evaluating QoL after hip fracture surgery.[24]

The BI is a ranking system that evaluates a patient's functional independence.[25] This scale comprises ten daily living activities, including bowel function, bladder function, grooming, toilet use, feeding independence, transfer independence, mobility, dressing ability, stair use, and bathing. Scores on this scale range from 0 to 100, with higher scores indicating greater independence in daily living. Patients with higher scores demonstrate a higher level of ability to live independently. The BI is also used to monitor improvements in disability over time.[26]

The SPMSQ is a widely used screening tool to assess an individual's mental acuity and cognitive function,[27] consisting of questions and tasks that evaluate memory, orientation, and basic mathematical skills. It is commonly employed in the geriatric population to identify potential cognitive impairment or dementia in patients.

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS - version 24.0 for Windows, IBM Corp.). The Shapiro-Wilk test was performed to reveal the distribution of the data. Descriptive statistics were employed to summarize categorical variables in frequencies and proportions; continuous variables were summarized using means and standard deviations for normally distributed data or medians and interquartile ranges for non-normally distributed data. Comparative analyses were conducted using unpaired t-test for parametric variables, Mann-Whitney U-test for nonparametric variables, and Chi-square test for categorical variables. We used the Wilcoxon Signed Ranks test to compare the EQ-5D and BI scores between two time points. The results were considered statistically significant with a *P*-value less than 0.05.

Results

Our cohort included a total of 500 patients (149 males and 351 females), with a mean age of 81.05 ± 9.31; the oldest was 103, and the youngest was 60. Thirty-seven patients presented SHFs, accounting for 7.40%. There were

58 patients (11.60%) who died within 1 year, including 53 in 464 IHF patients (11.42%) and 5 in 37 SHF patients (13.51%); the difference in the mortality rate between SHF and IHF groups was not statistically significant (P = 0.702).

After matched pairing with age, sex, and CCI classification, 96 patients were included, with 64 IHFs and 32 SHFs. The median age was 86, the oldest was 99, and the youngest was 66. Women (n = 78, 81.25%) were seen more than men (n = 18, 18.75%). Table 1 shows no statistically significant differences in anthropometric data and socioeconomic factors between IHF and SHF patients.

Admission characteristics are summarized in Table 2. No significant differences were observed between the SHF and IHF groups regarding QoL (EQ-5D: 6 vs. 5, P = 0.073), functional independence (BI score: 90 vs 95, P = 0.123), or mental status (SPMSQ: 3 vs. 1, P = 0.064). Among 96 hip fracture patients, there were 57 femoral neck fractures, 36 trochanteric fractures, and 3 subtrochanteric fractures. Forty hip arthroplasties and 56 osteosyntheses were performed. There were no significant differences in fracture types (P = 0.444) and treatment methods (P = 0.306) between the two groups. Patients with IHF had significantly poorer bone quality than SHF

Table 1. Participant demographics.

Variables	Total N = 96	IHF n = 64	SHF n = 32	*P*-value
Age	86 [82.5-89]	86 [82.50-89.00]	86 [82.00-89.00]	0.969[1]
Sex				1.000[2]
Male	18 (18.25)	12 (18.75)	6 (18.75)	
Female	78 (81.25)	52 (81.25)	26 (81.25)	
Height (cm)	155 [150.00-158.00]	155 [150.00-158.65]	155 [151.00-158.00]	0.420[1]
Weight (kg)	53.96 ± 9.79	52.79 ± 8.61	56.3 ± 11.59	0.136
Body mass index (kg/m^2)	22.6 [20.05-24.40]	22.08 ± 2.91	23.35 ± 4.71	0.170
Education				0.922[2]
Primary school and below	65 (67.71)	42 (65.62)	23 (71.87)	
Junior high school	9 (9.37)	6 (9.38)	3 (9.38)	
Senior high school	11 (11.46)	8 (12.50)	3 (9.38)	
University and above	11 (11.46)	8 (12.50)	3 (9.37)	
Marriage status				0.779[2]
Married	57 (59.37)	37 (57.81)	20 (62.50)	
Widow	34 (35.42)	23 (35.93)	11 (34.38)	
Unmarried	3 (3.13)	2 (3.13)	1 (3.12)	
Divorce	2 (2.08)	2 (3.13)	0 (0)	
Coliving				0.411[2]
Living with family	77 (80.21)	52 (81.25)	25 (78.12)	
Living alone	9 (9.37)	7 (10.94)	2 (6.25)	
Nursing care institutions	10 (10.42)	5 (7.81)	5 (15.63)	
Caregiver				0.313[2]
Family	68 (70.83)	48 (75.00)	20 (62.50)	
Nursing care institution	7 (7.29)	4 (6.25)	3 (9.37)	
Domestic helpers	18 (18.75)	10 (15.62)	8 (25.00)	
Friends or neighbors	2 (2.08)	2 (3.13)	0 (0)	
Nursing	1 (1.05)	0 (0)	1 (3.13)	
Occupation				0.453[2]
Public	2 (2.08)	2 (3.13)	0 (0)	
Merchants	1 (1.05)	1 (1.56)	0 (0)	
Service industry	3 (3.12)	3 (4.68)	0 (0)	
None	63 (65.62)	42 (65.63)	21 (65.63)	
Retirement	27 (28.13)	16 (25.00)	11 (34.37)	

IHF: Initial hip fracture.
SHF: Second hip fracture.
Data were demonstrated under Mean ± Standard Deviation or Median [Interquartile Range] or n (%).
[1] Mann-Whitney U Test.
[2] Chi-square test.

Table 2. Admission Characteristics.

Variables	IHF n = 64	SHF n = 32	*P*-value
Charlson Comorbidity Index	1 [0-8]	1 [0-5]	0.766[1]
Quality of Life			
EQ-5D	5 [5-7]	6 [5-7.5]	0.073[1]
Mental status			
SPMSQ	1 [0-4.5]	3 [0.5-8]	0.064[1]
Activities of Daily Living			
Barthel Index	95 [87.5-100]	90 [77.5-100]	0.123[1]
Blood tests			
Hemoglobin (g/dL)	12.08 ± 1.82	12.14 ± 1.57	0.872[2]
Platelet ($x10^3/\mu L$)	193 [157.50-243.00]	170 [155.00-193.00]	0.108[1]
WBC ($10^9/L$)	9.22 ± 3.19	9.71 ± 2.66	0.427[2]
Creatinine (mg/dL)	0.84 [0.68-1.24]	0.75 [0.64-1.08]	0.242[1]
Albumin (g/dL)	3.16 ± 0.40[a]	3.06 ± 0.32	0.171[2]
Fracture types			
Femoral neck	38 (59.37)	19 (59.38)	0.444[3]
Trochanteric	23 (35.94)	13 (40.62)	
Subtrochanteric	3 (4.67)	0 (0)	
Treatment methods			
Hip arthroplasty	29 (45.31)	11 (34.38)	0.306[3]
Osteosynthesis	35 (54.69)	21 (65.62)	
Muscle strength			
Grip strength (kg)	9.40 [5.95-13.60]	9.85 [6.75-13.85]	0.594[1]
Grip strength/BMI	0.46 [0.28-0.66]	0.45 [0.25-0.68]	0.941[1]
Bone mineral density			
T-score	−3.98 ± 1.20	−3.31 ± 1.28	0.016[2]*

IHF: Initial hip fracture.
SHF: Second hip fracture.
WBC: White blood cell.
SPMSQ: The Short Portable Mental Status Questionnaire.
EQ-5D: EuroQol-5D questionnaire.
BMI: Body mass index.
Data were demonstrated under Mean ± Standard Deviation or Median [Interquartile Range] or n (%).
[a] n = 61.
[1] Mann-Whitney U Test.
[2] Unpaired t-test.
[3] Chi-square test.
* Statistically significant.

patients (T-score: −3.98 vs. −3.31, $P = 0.016$). The two groups also had no significant differences in blood test results or handgrip strength.

As shown in Table 3, 71 (74%) patients received AOMs, including selective estrogen-receptor modulators, bisphosphonate, denosumab, or teriparatide after surgery, with no significant difference in anti-osteoporosis intervention between the two groups ($P = 0.742$). The rate of patients having severe osteoporosis who got AOMs reached 83.5%. One year post-surgery, SHF patients showed significant improvements in QoL (EQ-5D: 6 to 7, $P = 0.005$), as did IHF patients (EQ-5D: 5 to 6.5, $P < 0.001$). However, both groups experienced a marked decline in functional independence, with SHF patients' median BI scores decreasing from 90 to 85 ($P = 0.005$) and IHF patients' scores dropping from 95 to 90 ($P < 0.001$). Despite these changes, both SHF and IHF patients maintained high life quality and ADL, with no significant differences found between the two groups (EQ-5D: 7 vs. 6.5, $P = 0.177$; and BI scores: 85 vs. 90, $P = 0.161$).

Discussions

This study involved a cohort of 500 patients who underwent surgery for hip fractures. Our analyses focused on a subset of 32 individuals with SHF and a control group comprising 64 patients with IHF, ensuring homogeneity in age, sex, and CCI classification. Both groups exhibited no significant differences in demographics, baseline characteristics, and clinical outcomes at the 1-year follow-up.

Table 3. Post-operative Anti-osteoporosis Treatment and Clinical Outcome Comparison at 1-Year Follow-up Between Two Groups.

Variables	IHF n = 64	SHF n = 32	*P*-value
Anti-osteoporosis medication	48 (75)	23 (71.86)	0.742[1]
Selective estrogen-receptor modulators	2 (4.17)	0	
Bisphosphonate	9 (18.75)	7 (30.43)	
Denosumab	33 (68.75)	15 (65.22)	
Teriparatide	4 (8.33)	1 (4.35)	
Quality of Life (EQ-5D)			
Baseline	5 [5-7]	6 [5-7.5]	0.073[2]
1-year follow-up	6.5 [5-8.5]	7 [6-9]	0.177[2]
P-value	< 0.001[3]*	0.005[3]*	
Activities of Daily Living (Barthel Index)			
Baseline	95 [87.5-100]	90 [77.5-100]	0.123[2]
1-year follow-up	90 [60-100]	85 [50-92.5]	0.161[2]
P-value	< 0.001[3]*	0.001[3]*	
Change at 1-year follow-up from baseline			
EQ-5D	0 [0-0]	1.5 [0-1.5]	0.423[2]
Barthel Index	−5 [-20 to −5]	−10 [-27.5 to −10]	0.601[2]

IHF: Initial hip fracture.
SHF: Second hip fracture.
EQ-5D: EuroQol-5D questionnaire.
Data were demonstrated under n (%) or Median [Interquartile Range].
[1] Chi-square Test.
[2] Mann-Whitney U Test.
[3] Wilcoxon Signed Ranks Test.
* Statistically significant.

These findings suggested that an SHF did not independently indicate unfavorable outcomes following hip fracture in the elderly population.

In our cohort, the overall mortality rate was low, accounting for 11.6%, which was consistent with prior studies.[3,22,28-30] The mortality rate after SHF was seen as higher than IHF at one year. Numerous studies also reported similar trends of increased mortality in SHF patients.[15,16,31] This could be attributed to these patients experiencing greater frailty and deteriorating health conditions, requiring more intensive care and intervention.

Our matched-pair patients exhibited significantly decreased QoL and functional independence after 1 year, comparable with previous studies.[14,24,32,33] Many factors like advanced age, pre-existing morbidities, time intervals between fractures, and comprehensive rehabilitation programs played a significant role in determining outcomes.[7,34,35] A prior cohort study comparing 246 IHF with 42 SHF cases highlighted SHF's impact in increasing the risk of readmission and mortality, independent of variations in demographic factors, comorbidities, or multiple medications.[8] Other authors argued that the increasing age is a more significant factor in the elevated risk of death than the SHF itself after hip fractures.[36] Moreover, Solou et al.[12] underscored the significance of geriatric nursing support in facilitating functional recovery after recurrent hip fractures. Our study found that, when controlling for age, sex, and comorbidities, SHF patients demonstrated similar levels of independence and QoL as those with IHF patients one year after surgery. These results aligned with a previous study.[16] The notion that an SHF did not indicate poorer outcomes than an IHF provided a more optimistic outlook for the patients and healthcare providers. It highlighted the importance of comprehensive care, preventive strategies, and personalized rehabilitation in managing hip fractures, whether it was their first or second one.

Dementia is a significant risk factor for hip fractures.[37,38] Mitani et al.[39] conducted a study of 384 patients with a mean age of 83.1 and confirmed dementia to be a risk factor for SHF, while 85.7% of the recurrent hip fractures occurred within three years of their first fractures. Several factors, including advanced age, osteoporosis, vitamin D deficiency, and high falling risk, were reported to be serious issues for elderly individuals with dementia, often leading to fractures.[40-42] In our study, although the SPMSQ score differences between the IHF and SHF groups were not statistically significant, SHF patients made more errors than those in the IHF group. Therefore, it is essential to identify elderly patients with dementia, especially after hip fractures, and implement comprehensive management and preventative

measures to avoid future injuries and reduce the risk of fractures.[42,43]

Our IHF patients had poorer bone quality than SHF patients. This result was familiar to Helynen et al.'s study[44], which showed a substantially lower T-score in IHF than in SHF patients (T-score = −2.4 vs. −1.0, respectively, $P = 0.016$). This could be attributed to anti-osteoporosis management after the first hip fracture. Nevertheless, the treatment given to our patients might not have been effective, as their T-score values fell significantly lower than the World Health Organization's criteria for severe osteoporosis (T-score below −2.5 with previous fractures).[45] Prior studies have established an inverse correlation between bone mineral density measured under the T-score and the risk of frailty fracture.[46,47] This emphasized the importance of early detection of osteoporosis in elderly patients deemed at high risk and suggested practitioners provide appropriate intervention to slow down the bone loss process and reduce subsequent fracture risk.

Several limitations should be considered in this study. Firstly, our patients were recalled from a single medical center, which might restrict the generalizability of findings to broader populations. Secondly, the rehabilitation program and anti-osteoporosis treatment were personalized for every patient, which could cause bias in the management and outcomes. Thirdly, functional outcomes were assessed based on patient- or caregiver-reported data without utilizing an additional objective tool, potentially affecting accuracy. Finally, a one-year follow-up period might be insufficient for thoroughly assessing the long-term impact of an SHF on patient outcomes.

Nevertheless, our study indicated that SHF was not an independent predictor for poor outcomes. With suitable intervention and rehabilitation, the performance of patients after SHF is comparable to that of those with IHF. The remaining higher mortality rate in SHF patients requires further investigations to explore the underlying factors influencing individuals sustaining subsequent hip fractures, ultimately paving the way for more effective preventive strategies and rehabilitation programs.

Conclusion

Elderly patients are at a heightened risk of hip fractures, which can lead to a substantial decline in their QoL and impairments in their functional and mental state. Despite the significant challenges presented by hip fractures, the one-year postoperative outcomes did not differ between IHF and SHF patients, suggesting that SHF is not an independent predictor for poor outcomes following hip fracture in the elderly population.

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Author Contribution

BTT. Nguyen: Methodology, Formal analysis, Investigation, Resources, Writing – Original Draft
S-W. Huang: Validation, Investigation, Data Curation, Writing – Original Draft
Y-J. Kuo: Writing – Review & Editing, Visualization, Supervision
TT. Nguyen: Formal analysis, Visualization, Writing – Review & Editing
Y-P. Chen: Conceptualization, Methodology, Resources, Writing – Review & Editing, Project administration, Funding acquisition. Y-P. Chen took responsibility as the corresponding author. All authors have read and approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical Statement

Ethical Approval

The Ethical Committee of Taipei Medical University approved the entire protocol and all instruments used (ethical approval number: TMU-JIRB N201709053). All participants provided written informed consent for their participation and the publication of this study.

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Supplemental Material

Supplemental material for this article is available online.

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