**Original Article - Pediatric Urology**

Investig Clin Urol 2022;63:448-454.
https://doi.org/10.4111/icu.20220122
pISSN 2466-0493 • eISSN 2466-054X

INVESTIGATIVE AND CLINICAL UROLOGY
ICUROLOGY

# The incidence of testicular torsion and testicular salvage rate in Korea over 10 years: A nationwide population-based study

**Jin Bong Choi[1], Kyu Hun Han[1], Yunhee Lee[2], U-Syn Ha[2], Kang Jun Cho[1], Joon Chul Kim[1], Jun Sung Koh[1]**

*[1]Department of Urology, Bucheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, [2]Department of Urology, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea*

**Purpose:** We performed a nationwide epidemiological study of testicular torsion using the National Health Insurance System database for the entire male population of Korea.

**Materials and Methods:** Age, sex, socioeconomic status, regional information, and diagnostic codes were retrieved from January 2009 to December 2019. To clearly identify the diagnosis of testicular torsion, patients who had not undergone orchiectomy or orchiopexy were excluded from the study. Multivariable logistic regression models were used to analyze the association between demographic characteristics and testicular loss.

**Results:** The overall incidence of testicular torsion in males was 2.02 cases per 100,000 person-years and 6.99 cases per 100,000 person-years in males under 19 years of age. Testicular torsion most commonly occurred either in infancy or adolescence. The total testicular salvage rate was 75.22% and highest in children at 79.91%. The rate of orchiectomy was high in infancy and in the oldest patients. We determined that age distribution was related to the risk of testicular loss.

**Conclusions:** This study is the first nationwide epidemiological study of testicular torsion, which contains the entire Korean population. Although the testicular salvage rate in Korea was higher compared to other countries, it is necessary to educate males under 19 years of age on the seriousness of acute testicular pain to minimize the possibility of testicular loss.

**Keywords:** Epidemiology; Orchiectomy; Orchiopexy; Spermatic cord torsion; Testis



## INTRODUCTION

Testicular torsion occurs when the spermatic cord twists. The process cuts off the blood supply to the testis and the reduced blood flow causes severe pain and swelling [1,2]. This condition has been demonstrated to cause a long-term decrease in sperm motility and reduce overall sperm counts, leading to subfertility or infertility in men [3]. Because the testis can usually be saved if treated quickly, testicular torsion requires emergency surgery. The optimal timing is less than 6 hours after symptom onset, which allows for approximately 90% testicular salvage [4].

The epidemiology of testicular torsion shows a bimodal peak in infancy and adolescence [5]. Nationwide studies carried out in several countries have reported an incidence of testicular torsion from 3.5 to 4.5 cases per 100,000 person-

**Received:** 20 March, 2022 • **Revised:** 19 April, 2022 • **Accepted:** 2 May, 2022 • **Published online:** 31 May, 2022
**Corresponding Author:** Jun Sung Koh https://orcid.org/0000-0001-7432-4209
Department of Urology, Bucheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 327 Sosa-ro, Wonmi-gu, Bucheon 14647, Korea
TEL: +82-32-340-7070, FAX: +82-32-340-2124, E-mail: gostraight@catholic.ac.kr

years in males under 25 years of age [5-7]. The Korean Urological Association also collected the testicular torsion registry using the Urologic Partitioned Data Set (UroPDS) from 2006 to 2011. This database includes the inpatient information of all the training hospitals in Korea. The overall incidence of testicular torsion in males was 1.1 cases per 100,000 person-years and the incidence for males under 25 years of age was 2.9 cases per 100,000 person-years from 2006 to 2011 [8]. However, these results might have been underestimated since only training hospitals were included in the database and some data were lost due to missing records.

Therefore, we performed a nationwide epidemiological study of testicular torsion in Korea using the National Health Insurance System (NHIS) database, which contains the entire Korean population. Furthermore, we determined the current salvage rates for testicular torsion and identified the risk factors for testicular loss.

## MATERIALS AND METHODS

### 1. Study population

The NHIS database of Korea is a public database comprising the eligibility database, the national health screening database, the healthcare utilization database, and the long-term care insurance database. In the present study, age, sex, socioeconomic status, regional information, and diagnostic codes based on the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) were retrieved from January 2009 to December 2019. Testicular torsion was coded as N44. Surgeons must enter a specific code for the operation performed in the NHIS to bill the correct insurance costs. For our analyses, testicular surgery included orchiectomy (R3851) and orchiopexy (R3880 or R3882). The patients classified in the testicular loss group were those with only an orchiectomy code without an orchiopexy code. To clearly identify the diagnosis of testicular torsion, patients who had not undergone orchiectomy or orchiopexy were excluded from the study.

Age was divided into groups of infants (0–1 years), children (2–9 years), adolescents (10–19 years), and adults (20–29 years, 30–39 years, 40–49 years, and ≥50 years) according to the World Health Organization definition. The geographic regions were divided into 17 administrative zones: 6 metropolitan cities, 1 special city, 1 special self-governing city, and 9 provinces (including one special self-governing province). Household income was calculated as family income, adjusting for the number of family members, and divided into 4 equal parts (Q1: the lowest 25%, Q2: the next lowest 25%, Q3: the second-highest 25%, and Q4: the highest 25%).

### 2. Statistical analysis

SAS software (version 9.4, SAS Institute, Cary, NC, USA) was used for the statistical analyses. The baseline characteristics of the subjects are presented as the number (%) for categorical variables and a chi-squared test was used to test for statistical significance. The incidence rate is expressed as the number of newly diagnosed cases of testicular torsion per 100,000 person-years. Multivariable logistic regression analysis was conducted to examine the odds ratio (OR) and 95% confidence interval (CI) for the association between demographic characteristics and testicular loss. Statistical significance was verified at a level of 0.05.

### 3. Ethics approval

This study was approved by the Institutional Review Board of the Catholic University of Korea (approval no. HC21ZISI0024). Informed consent was waived because anonymous and de-identified information was used for analysis.

## RESULTS

### 1. Incidence of testicular torsion

A total of 5,694 males presenting with testicular torsion underwent surgical management between 2009 and 2019 (Table 1). The average yearly incidence of testicular torsion for males was 2.02 per 100,000 person-years and 6.99 per 100,000 person-years in males under 19 years of age. There were two peaks of incidence at infancy and adolescence. Testicular torsion was most common in males aged 10 to 19 years with an incidence of 10.46 cases per 100,000 person-years, followed by males 0 to 1-year-old with an incidence

**Table 1.** Trends in the total number of patients who underwent surgery for testicular torsion

| Year | Testicular torsion | Male population | Incidence rate[a] | Orchiectomy | Orchiopexy |
|---|---|---|---|---|---|
| 2009 | 406 | 24,929,939 | 1.63 | 121 (29.80) | 285 (70.20) |
| 2010 | 489 | 25,310,385 | 1.93 | 138 (28.22) | 351 (71.78) |
| 2011 | 480 | 25,406,934 | 1.89 | 120 (25.00) | 360 (75.00) |
| 2012 | 554 | 25,504,060 | 2.17 | 150 (27.08) | 404 (72.92) |
| 2013 | 514 | 25,588,336 | 2.01 | 128 (24.90) | 386 (75.10) |
| 2014 | 569 | 25,669,296 | 2.22 | 141 (24.78) | 428 (75.22) |
| 2015 | 552 | 25,758,186 | 2.14 | 115 (20.83) | 437 (79.17) |
| 2016 | 562 | 25,827,594 | 2.18 | 136 (24.20) | 426 (75.80) |
| 2017 | 528 | 25,855,919 | 2.04 | 125 (23.67) | 403 (76.33) |
| 2018 | 537 | 25,866,129 | 2.08 | 129 (24.02) | 408 (75.98) |
| 2019 | 503 | 25,864,816 | 1.95 | 108 (21.47) | 395 (78.53) |
| Total | 5,694 | 281,581,594 | 2.02 | 1,411 (24.78) | 4,283 (75.22) |

Values are presented as number only or number (%).
[a]:All rates are expressed as number per 100,000 person-years.

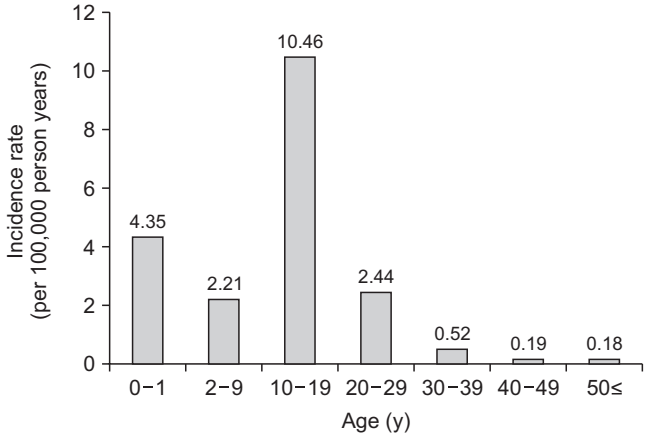


**Fig. 1.** Incidence rate of testicular torsion by age distribution.

of 4.35 cases per 100,000 person-years (Fig. 1). According to the geographic region, testicular torsion most commonly occurred in Gwangju metropolitan city, with an incidence of 2.95 cases per 100,000 person-years, and the lowest occurrence was found in South Chungcheong Province, with an incidence of 1.51 cases per 100,000 person-years (Table 2).

When the incidence of testicular torsion was evaluated based on the month and season, testicular torsion most commonly occurred in January, which accounted for 10.57% of the cases. The seasonal incidence of testicular torsion was 24.99%, 20.14%, 24.87%, and 30.00% in spring (March, April, and May), summer (June, July, and August), autumn (September, October, and November), and winter (December,

**Table 2.** The total number of patients who underwent surgery for testicular torsion according to geographic region

| Geographic region | Testicular torsion | Male population | Incidence rate[a] | Orchiectomy | Orchiopexy |
|---|---|---|---|---|---|
| Seoul special city | 1,069 | 54,429,296 | 1.96 | 270 (25.26) | 799 (74.74) |
| Busan metropolitan city | 367 | 19,077,639 | 1.92 | 91 (24.80) | 276 (75.20) |
| Daegu metropolitan city | 251 | 13,611,112 | 1.84 | 56 (22.31) | 195 (77.69) |
| Incheon metropolitan city | 322 | 15,896,877 | 2.03 | 60 (18.63) | 262 (81.37) |
| Gwangju metropolitan city | 235 | 7,974,853 | 2.95 | 55 (23.40) | 180 (76.60) |
| Daejeon metropolitan city | 149 | 8,302,415 | 1.80 | 49 (32.89) | 100 (67.11) |
| Ulsan metropolitan city | 122 | 6,514,847 | 1.87 | 32 (26.23) | 90 (73.77) |
| Sejong special self-governing city | 16 | 892,367 | 1.79 | 5 (31.25) | 11 (68.75) |
| Gyeonggi Province | 1,579 | 68,609,505 | 2.30 | 384 (24.32) | 1,195 (75.68) |
| Gangwon Province | 151 | 8,528,190 | 1.77 | 43 (28.48) | 108 (71.52) |
| North Chungcheong Province | 172 | 8,744,121 | 1.97 | 46 (26.74) | 126 (73.26) |
| South Chungcheong Province | 175 | 11,611,646 | 1.51 | 46 (26.29) | 129 (73.71) |
| North Jeolla Province | 199 | 10,185,253 | 1.95 | 55 (27.64) | 144 (72.36) |
| South Jeolla Province | 208 | 10,464,985 | 1.99 | 64 (30.77) | 144 (69.23) |
| North Gyeongsang Province | 232 | 14,871,397 | 1.56 | 36 (15.52) | 196 (84.48) |
| South Gyeongsang Province | 368 | 18,477,805 | 1.99 | 95 (25.82) | 273 (74.18) |
| Jeju special self-governing province | 79 | 3,389,286 | 2.33 | 24 (30.38) | 55 (69.62) |
| Total | 5,694 | 281,581,594 | 2.02 | 1,411 (24.78) | 4,283 (75.22) |

Values are presented as number only or number (%).
[a]:All rates are expressed as number per 100,000 person-years.

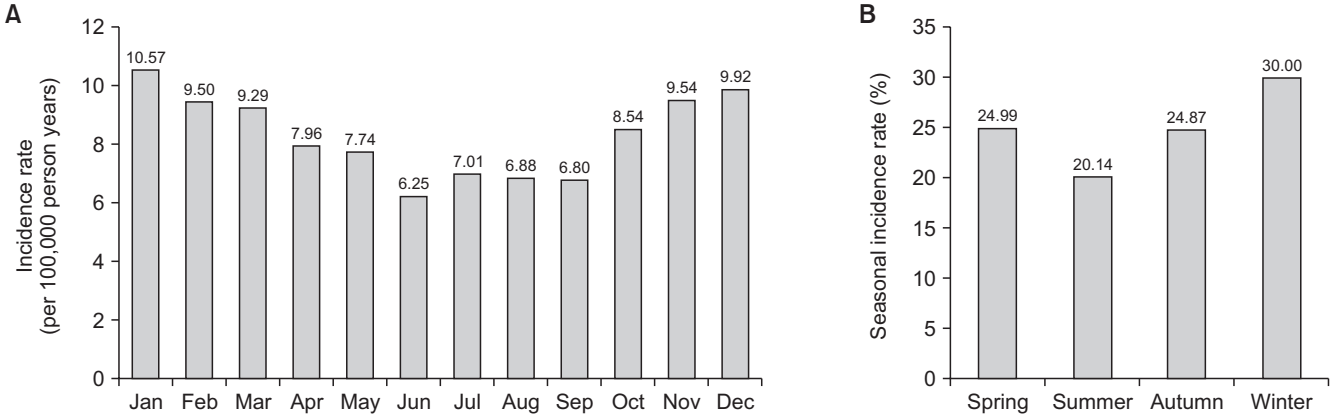


**Fig. 2.** Monthly (A) and seasonal (B) incidence rates of testicular torsion.



https://doi.org/10.4111/icu.20220122

January, and February), respectively (Fig. 2). The incidence of testicular torsion was significantly increased in winter compared to the other seasons (p<0.001).

### 2. Risk of testicular loss

Orchiectomy was performed in 24.78% of the males undergoing surgery for torsion in total age. The rate of orchiectomy was high in males aged 0 to 1 year (45.37%) and males over 50 years old (74.38%) (Fig. 3). The total testicular salvage rate was 75.22% and highest in children at 79.91%. According to the geographic regions, the rate of orchiectomy was highest in Daejeon metropolitan city (32.89%) and lowest in North Gyeongsang Province (15.52%).

Multivariable logistic regression models were used to analyze the association between age group and the OR of testicular loss. The OR for testicular loss was lowest in males aged 2 to 9 years (the reference age) and highest in males over 50 years old in the multivariate-adjusted model (OR, 11.32; 95% CI, 7.43–17.26). The group with the second-highest testicular loss was infants (OR, 3.31; 95% CI, 2.32–4.73) (Table 3). Differences in geographic regions or socioeconomic status showed no significantly meaningful trend in testicular loss.

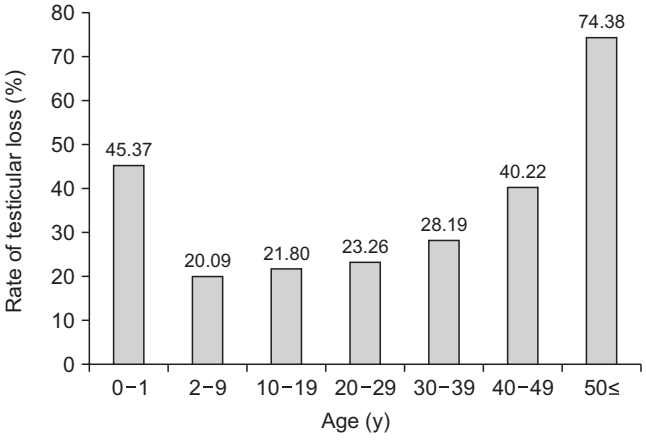


**Fig. 3.** Rate of testicular loss according to age distribution.

## DISCUSSION

The main findings of this nationwide population-based study were: (1) in Korea, the overall incidence of testicular torsion in males was 2.02 cases per 100,000 person-years and 6.99 cases per 100,000 person-years in males under 19 years of age; (2) testicular torsion most commonly occurred either in infancy or adolescence; (3) the incidence of testicular torsion was significantly increased in winter compared to other seasons; (4) the total testicular salvage rate was 75.22% and was highest in children at 79.91%; and (5) the rate of orchiectomy was high in the youngest (45.37%) and oldest patients (74.38%). We determined that age distribution was related to the risk of testicular loss.

The incidence of testicular torsion in males under 25 years of age has been reported to be 4.5 cases per 100,000 person-years in the United States (U.S.) [7]. Another cohort analysis performed in the U.S. reported that the yearly incidence of testicular torsion in males under 18 years of age was 3.8 cases per 100,000 person-years. A nationwide study in Taiwan also reported 3.5 cases per 100,000 person-years in males under 25 years of age [6]. The overall incidence of testicular torsion in Brazil was 1.4 cases per 100,000 persons in 2010 [9]. Our study showed a slightly higher incidence rate in than these countries.

Certain factors may increase the risk of testicular torsion. Age is one of the important risk factors for testicular torsion. Torsion most commonly occurs either in infancy or adolescence, as shown in this study. Prenatal torsions are predominantly extra-vaginal and about 50% of testicular torsion in infancy occurs prenatally [10]. Prolonged labor, gestational diabetes, preeclampsia, twin pregnancy, and

**Table 3.** Multivariable-adjusted ORs for testicular loss according to age

| Age | Testicular torsion | Male population | Incidence rate[a] | Testicular loss | OR (95% CI) | |
|---|---|---|---|---|---|---|
| | | | | | Model 1[b] | Model 2[c] |
| 0–1 | 205 | 4,708,933 | 4.28 | 93 | 3.30 (2.31–4.71) | 3.31 (2.32–4.73) |
| 2–9 | 468 | 21,217,087 | 2.19 | 94 | Ref. | Ref. |
| 10–19 | 3,592 | 34,325,178 | 10.32 | 783 | 1.11 (0.87–1.41) | 1.11 (0.88–1.41) |
| 20–29 | 950 | 38,955,509 | 2.45 | 221 | 1.21 (0.92–1.58) | 1.19 (0.91–1.56) |
| 30–39 | 227 | 43,893,173 | 0.52 | 64 | 1.56 (1.08–2.25) | 1.54 (1.07–2.23) |
| 40–49 | 92 | 49,027,748 | 0.19 | 37 | 2.68 (1.67–4.30) | 2.68 (1.67–4.30) |
| ≥50 | 160 | 89,453,966 | 0.17 | 119 | 11.55 (7.58–17.59) | 11.32 (7.43–17.26) |

OR, odds ratio; CI, confidence interval.
[a]:All rates are expressed as number per 100,000 person-years.
[b]:Non-adjusted.
[c]:Adjusted for geographic regions and socioeconomic status.

high birth weight have been associated with the risk of prenatal testicular torsion [11]. The majority of cases occur in adolescence usually due to a congenital abnormality of the processus vaginalis called bell clapper deformity [12]. In adolescence, the rapid growth of the testes during puberty may cause the testis to flop and twist.

Cold temperature may also be a risk factor. Several previous studies reported an increased incidence of testicular torsion in colder weather [13-16]. Our results also showed seasonal variation in the incidence of testicular torsion with a significant increase in events during winter. Hoshino et al. [14] reported that 76% of the testicular torsions occurred below 15ºC and there was a significant correlation between decreases in temperature and onset frequency. Srinivasan et al. [16] reported that 81% of testicular torsions occurred below 15ºC, and found an increased incidence of testicular torsion with decreasing temperature and humidity. They suggested that hyperactivity of the cremasteric reflex stimulated by cold weather might be the pathophysiology of testicular torsion. However, some studies have reported conflicting evidence [17,18]. Therefore, further studies are required to understand the association between climatic factors and the incidence of testicular torsion.

In this study, the total testicular salvage rate was 75.22%. The rate of testicular salvage in children (aged 2–9 years) was highest at 79.91%. This testicular salvage rate was slightly higher than that in other countries. In the U.S., Greear et al. [19] reported that orchiectomy was performed in 33.6% of a population encompassing all ages. In another study, orchiectomy was performed in 41.9% of boys (under 18 years of age) undergoing surgery for torsion [20]. Cost et al. [17] reported that 31.9% underwent orchiectomy at a mean age of 10.7 years and 68.1% underwent orchiopexy at a mean age of 12.6 years. It was reported that 74.4% of patients younger than 25 years had undergone orchiopexy in Taiwan [6].

One possible explanation for better salvage rate in Korea is the accessibility of quality medical services. Dense distribution of hospitals in a relatively small country makes it easy to find urologists within the golden hour. Since the NHIS covers certain proportion of the medical expenses of every Korean citizen, most Koreans present to hospital without worrying about high hospital bills. Easy access to hospitals with low costs has led to closing the gap between rural and urban areas as well as between different socioeconomic classes with respect to access to health care [21]. For these reasons, in this study, disparities between geographic regions (between rural and urban areas) and socioeconomic status showed no significantly meaningful trend in testicular loss.

However, we determined that age was related to the risk of testicular loss. In infancy, 45.37% of the cases of testicular torsion led to orchiectomy, while most adolescent patients underwent orchiopexy (78.2%). Since adolescents have the ability to articulate their symptoms, they visit a hospital in a timely manner. However, infants are unable to express scrotal pain. Thus, diagnosis and treatment are inevitably delayed. In addition, neonatal testicular torsion is generally asymptomatic, making it difficult to diagnose [22].

Furthermore, the rate of orchiectomy was increased linearly with age and highest in the oldest patients (74.38%) in this study. Greear et al. [19] reported that the risk of orchiectomy was highest in patients over 50 years of age in the U.S. at 69.7%. Cummings et al. [23] also showed a different salvage rate, where 70.3% of testes salvaged in the younger group versus only 41% of testes salvaged in the older group. This can be partly explained by the factors related to aging, such as decreased sensitivity to pain and the rapid onset of ischemia due to vascular disorders, which may contribute to a delay in diagnosis. In addition, testicular torsion is an active litigious area in the urology department because testicular loss secondary to torsion is a potential source of medical claims [24,25]. Since testicular loss in younger patients can lead to more legal problems than those in older age, physicians tend to be more aggressive and conduct early exploration in younger aged patients. Finally, attempting to salvage an obviously necrotic testis increases the risk of abscess formation at old ages.

One limitation to our study was that testicular torsion was classified based only on the ICD code. For this reason, miscoding may have occurred in patients with symptoms similar to those of testicular torsion. Thus, we excluded patients who did not undergo subsequent surgical intervention (orchiectomy or orchiopexy) to clearly confirm the diagnosis of testicular torsion. However, males who did not undergo surgical intervention after manual reduction or did not visit the hospital even if they had acute symptoms might not have been included.

## CONCLUSIONS

To the best of our knowledge, this study is the first nationwide epidemiological study of testicular torsion, which contains the entire Korean population. The overall incidence of testicular torsion in males was 2.02 cases per 100,000 person-years and 6.99 cases per 100,000 person-years in males under 19 years of age. Testicular torsion most commonly occurred either in infancy or adolescence. Age distribution was also related to the risk of testicular loss. Although the tes-


https://doi.org/10.4111/icu.20220122

ticular salvage rate in Korea was higher compared to other countries, it is necessary to educate males under 19 years of age on the seriousness of acute testicular pain to minimize the possibility of testicular loss.

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

## FUNDING

This work was supported by the Institute of Clinical Medicine Research of Bucheon St. Mary's Hospital, Research Fund, 2021.

## AUTHORS' CONTRIBUTIONS

Research conception and design: Jin Bong Choi and Jun Sung Koh. Data acquisition: Jin Bong Choi, Kyu Hun Han, Yunhee Lee, Kang Jun Cho, Joon Chul Kim, and Jun Sung Koh. Statistical analysis: Jin Bong Choi, Yunhee Lee, and U-Syn Ha. Data analysis and interpretation: Jin Bong Choi, Kyu Hun Han, Yunhee Lee, Kang Jun Cho, Joon Chul Kim, and Jun Sung Koh. Drafting of the manuscript: Jin Bong Choi, Kyu Hun Han, and Jun Sung Koh. Critical revision of the manuscript: U-Syn Ha, Kang Jun Cho, and Joon Chul Kim. Obtaining funding: Jin Bong Choi. Administrative, technical, or material support: Yunhee Lee. Supervision: U-Syn Ha, Kang Jun Cho, and Joon Chul Kim. Approval of the final manuscript: all authors.

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