IMPORTANCE Visual impairment (VI) is an emerging public health concern, especially considering the aging population. However, unlike other major chronic diseases, VI is often overlooked by investigators assessing the burden of diseases.

OBJECTIVES To provide a description of preference weights for VI and chronic diseases from a national survey and estimate the corresponding burden of these diseases.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional study was conducted using a multistage, probability-cluster survey, which can produce nationally representative estimates. Data on 29,639 participants 19 years or older from the 2008-2012 Korean National Health and Nutrition Examination Survey were analyzed in terms of vision assessment, status of chronic diseases, and the European Quality of Life–Five Dimensions Questionnaire (EQ-5D). Visual impairment was defined as the presenting distance best-corrected visual acuity of worse than decimal 0.5. Data analysis was conducted from August 14, 2008, and September 7, 2015.

MAIN OUTCOMES AND MEASURES Preference weights (utilities) and prevalence-based quality-adjusted life-year (QALY) losses.

RESULTS Of the 29,639 participants, 28,382 with VA or EQ-5D measurements were included in the analysis; they had a mean (SE) age of 45.05 (0.19) years and a mean EQ-5D index of 0.948 (0.001). The preference weight for VI was −0.0549 (95% CI, −0.0777 to −0.0321), which was the third highest value among the 12 diseases analyzed—preceded only by the preference weights for osteoarthritis or rheumatoid arthritis (−0.0688; 95% CI, −0.0628 to −0.0628) and stroke (−0.0666; 95% CI, −0.0854 to −0.0479). The estimated annual QALY loss from VI was −74.93 years per 100,000 person-years; this loss is comparable to or higher than that associated with other major chronic conditions (eg, diabetes mellitus, dyslipidemia, stroke, myocardial infarction/ischemic heart disease, asthma, obesity, and anemia). Visual impairment accounted for 4.77% of the total estimated QALY loss in the Korean population aged 19 years or older.

CONCLUSIONS AND RELEVANCE The present study provides a description of preference weights for VI and various chronic diseases from a national survey. Furthermore, it reveals the distributions of public burden from these conditions, and compared them in this regard. Although details might vary across the populations having different cultural and socioeconomic backgrounds, the results underscore the importance of VI for quality of life and as a public health burden compared with other major chronic diseases.
As a result of the aging population, the public health burden of chronic diseases has sharply increased recently, especially in developed countries. Because health care resources are limited, assessing this burden is indispensable for public health planning and prioritization. The health-adjusted life-year is a summary measure of population health that allows comparisons across different chronic diseases and populations; various forms of the health-adjusted life-year (letters correct disability-adjusted life-years) have been used to investigate the global burden of chronic diseases.

However, the burden of visual impairment (VI) is overlooked more often than the burdens of other health conditions in certain populations. Nonetheless, VI is a public health concern that results in a considerable public health burden, and the number of persons with VI has sharply increased in the past 2 decades as the worldwide population has aged. In the case of vision, quality of life may be a better outcome measure than mortality and disability (ie, disability-adjusted life-years). The quality-adjusted life-year (QALY), a type of health-adjusted life-year, places weight on the time spent in different health states using a value that represents the quality of life during that time (year). Quality-adjusted life-years are estimated using preference-based measures known as utilities; these measures range from perfect health (1.0) to death (0). One of the most popular utility metrics is the European Quality of Life–Five Dimensions Questionnaire (EQ-5D); this questionnaire is the preferred method for utility estimation in the United Kingdom. Historically, the description of preference weights for chronic diseases often lacked an estimate regarding VI, especially VI as assessed using comprehensive visual acuity (VA) measurement. Furthermore, these descriptions did not include a sufficient number of chronic diseases, nor did they derive their values from a representative population; both of these elements are cornerstones of burden assessment using QALYs. Therefore, given the scarcity of comprehensive investigations, the aim of the present study was to estimate the preference weights and elucidate the distribution of the burdens of chronic diseases and VI; we used nationwide data that were representative of the South Korean population.

### Methods

#### Study Design and Population

This study analyzed the 5-year (2008-2012) data of the Korean National Health and Nutrition Examination Survey (KNHANES), which included a 5-year ophthalmic survey designed by the Korean Ophthalmological Society. The survey has been described in detail previously. Briefly, the KNHANES is an ongoing, population-based, cross-sectional survey in South Korea that is conducted by the Korea Centers for Disease Control and Prevention and the Korean Ministry of Health and Welfare. The 2008-2012 KNHANES randomly selected 3840 to 4600 households in 192 to 200 postal codes annually; in this way, the KNHANES represents the civilian, noninstitutionalized Korean population using a rolling sampling design that involves a multistage, probability-cluster survey. The KNHANES comprises a Health Interview Survey, a Health Examination Survey, and a Nutrition Survey; the present study analyzed deidentified data from the first 2 surveys. The institutional review board of the Seoul National Bundang Hospital approved this study and waived the need for informed consent. This study was conducted in accordance with the Declaration of Helsinki.

#### Measurement of Health-Related Quality of Life

All participants 19 years or older were asked to complete the validated Korean version of the EQ-5D, which defines 3 levels of self-reported problems (no problem, some problems, or extreme problems) within each of 5 dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression). The results were scored using the responses to the 5 dimensions and the South Korean population-based EQ-5D index score proposed by the Korea Centers for Disease Control and Prevention. This index score is based on the preference weights for South Koreans, which are in turn calculated from representative samples selected using the time trade-off method (-0.257 [worst health state] to 1.00 [perfect health state]). Because the EQ-5D is among the most preferred methods of utility measurement, we also used the EQ-5D index scores as preference weights (utilities) to analyze our QALY model. The definition of a QALY is “a measure of a person’s length of life, weighted by a valuation of their health-related quality of life,” and QALYs provide a common currency to assess the burden of diseases in terms of health-related quality of life.

### Definition of VI

All participants in the KNHANES who were 5 years or older underwent both VA and autorefractive testing (KR8800; Topcon). Uncorrected and/or corrected VA (decimal VA; using the individual’s own glasses/lenses) was measured at a distance of 4 m using an international standard vision chart that is based on the logMAR Scale (Jin’s vision chart). Participants with a VA of 0.8 (20/25 Snellen) or worse underwent best-corrected VA (BCVA) testing using autorefractive results. If participants could not read any number at 4 m, VA was measured at a distance of 1 m. Visual impairment was defined as a...
Burden of Visual Impairment and Chronic Diseases

**Determination of Chronic Diseases**

Based on previous studies, the demographic and socioeconomic covariates for the analyses were age, smoking status (never-smoker, ex-smoker, or current smoker), equalized gross household income (>50% or ≤50% household income), educational level (≥high school or ≤middle school), residence (urban or rural), occupation (white collar, blue collar, or unemployed), and living situation (living alone or living with ≥1 others). We also collected information regarding 12 chronic diseases that can considerably affect health-related quality of life: hypertension, diabetes mellitus, dyslipidemia, stroke, myocardial infarction or ischemic heart disease (MI/IHD), osteoarthritis or rheumatoid arthritis (OA/RA), pulmonary tuberculosis, asthma, renal failure, hepatitis B or C, obesity (body mass index ≥30) (calculated as weight in kilograms divided by height in meters squared)), and anemia (hemoglobin level <13 g/dL in men or <12 g/dL in women, measured using the XE-2100D [Sysmex, Japan]; to convert to grams per liter, multiply by 10). All of these variables were included in all multiple linear regression analyses and multiple logistic regression analyses.

**Statistical Analysis**

We included participants 19 years or older who had available VA and EQ-5D data. We tested the differences between the included and excluded participants in terms of frequencies and weighted prevalences. We then conducted a multiple linear regression analysis to estimate the effects of VI and chronic diseases on the EQ-5D index score; the regression coefficients for each condition were regarded as preference weights (utility scores) and comprised the description of preference weights for VI and the 12 chronic conditions evaluated. Using these estimated preference weights, we then calculated QALY loss (per 100 000 people) due to VI and each chronic health condition using the following formula:

Annual QALY loss per 100 000 people = preference weight × 100 000 people × 1 year × prevalence.

The prevalence estimates for VI and each condition were derived from all participants 19 years or older in the 2008-2012 KNHANES²⁷ (ie, not just from participants who had both VA and EQ-5D data). We examined the assumptions of the linear model using all-regression diagnostics. In addition, the same set of analyses were conducted in participants 40 years or older and 60 years or older to provide the differences in public burden from these conditions in the aged population and to allow comparison of our results with those of previous studies from other countries. For all analyses, the KNHANES sample weights were applied to adjust for survey design, nonresponse, and poststratification; in this way, we generated nationally representative population-based results.⁸,¹⁷,¹⁸ Statistical analyses were conducted using SAS, version 9.3 (SAS Inc), with the PROC SURVEY procedures accounting for the complex survey-sampling design. The NOMCAR (not missing completely at random) option was implemented to include variability for individuals with missing values. Data analysis was conducted from August 14, 2008, to September 7, 2015.

**Results**

Of the 29 639 persons 19 years or older who participated in the 2008-2012 KNHANES, 1257 were excluded because of a lack of VA or EQ-5D measurements; thus, 28 382 participants were included in the analysis to estimate preference weights (eTable 1 in the Supplement). The mean (SE) age was 45.05 (0.19) years and the mean EQ-5D index was 0.948 (0.001). A flowchart for the analysis is provided in Figure 1.

The preference weight for VI (a distance BCVA of <0.5 in the better-seeing eye) was −0.0549 (95% CI, −0.0777 to −0.0321), which was the third highest value, preceded only by OA/RA (−0.0688; 95% CI, −0.0748 to −0.0628) and stroke (−0.666; 95% CI, −0.0854 to −0.0479); the value was much higher than those of other chronic conditions. The estimated annual QALY loss from VI was −74.93 years per 100 000 people, which was comparable to or higher than those from other major chronic conditions (eg, diabetes, dyslipidemia, stroke, MI/IHD, asthma, obesity, and anemia). Visual impairment accounted for 4.77% of the total estimated QALY loss in the South Korean population 19 years or older. Unlike QALY loss due to other chronic conditions, that due to VI was similar in the aged populations (4.25% in participants aged ≥40 years, and 4.34% in those aged ≥60 years). Detailed estimated preference weights and annual QALY losses associated with each condition are provided in Table 1 and Figure 2. The results estimated in participants 40 years or older are provided in eTable 2 in the Supplement and those estimated in participants 60 years or...
Table 1. Preference Weights and Prevalence-Based QALY Losses at BCVA Worse Than 0.5a

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Prevalence, Weighted % (SE)</th>
<th>Preference Weight (95% CI)</th>
<th>Annual QALY Loss (%)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual impairmentc</td>
<td>1.37 (0.08)</td>
<td>−0.0549 (−0.0777 to −0.0321)</td>
<td>−74.93 (4.77)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>17.30 (0.32)</td>
<td>−0.0079 (−0.0125 to −0.0034)</td>
<td>−137.30 (6.74)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>6.38 (0.17)</td>
<td>−0.0134 (−0.0212 to −0.0056)</td>
<td>−85.37 (5.44)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>8.18 (0.19)</td>
<td>−0.0034 (−0.0097 to 0.0029)</td>
<td>−27.93 (1.78)</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.39 (0.07)</td>
<td>−0.0666 (−0.0854 to −0.0479)</td>
<td>−92.37 (5.88)</td>
</tr>
<tr>
<td>MI or IHD</td>
<td>1.98 (0.09)</td>
<td>−0.0213 (−0.0311 to −0.0094)</td>
<td>−42.08 (2.68)</td>
</tr>
<tr>
<td>OA or RA</td>
<td>12.49 (0.25)</td>
<td>−0.0688 (−0.0748 to −0.0628)</td>
<td>−859.72 (54.75)</td>
</tr>
<tr>
<td>Pulmonary Tb</td>
<td>5.08 (0.16)</td>
<td>−0.0071 (−0.0134 to −0.0008)</td>
<td>−36.06 (2.30)</td>
</tr>
<tr>
<td>Asthma</td>
<td>4.02 (0.15)</td>
<td>−0.0251 (−0.0340 to −0.0162)</td>
<td>−101.18 (6.44)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0.36 (0.04)</td>
<td>−0.0119 (−0.0360 to 0.0122)</td>
<td>−4.28 (0.27)</td>
</tr>
<tr>
<td>Hepatitis B or C</td>
<td>1.66 (0.10)</td>
<td>−0.0048 (−0.0153 to 0.0057)</td>
<td>−7.95 (0.51)</td>
</tr>
<tr>
<td>Obesityd</td>
<td>4.28 (0.16)</td>
<td>−0.0096 (−0.0172 to −0.0020)</td>
<td>−41.15 (2.62)</td>
</tr>
<tr>
<td>Anemiae</td>
<td>8.14 (0.20)</td>
<td>−0.0134 (−0.0193 to −0.0075)</td>
<td>−108.98 (6.94)</td>
</tr>
</tbody>
</table>

Abbreviations: BCVA, best-corrected visual acuity; IHD, ischemic heart disease; MI, myocardial infarction; OA, osteoarthritis; QALY, quality-adjusted life-year; RA, rheumatoid arthritis; Tb, tuberculosis.

* Prevalence estimates were derived from all 29,639 participants ≥19 years older. Adjustment factors were age, smoking status, household income, education, residence, occupation and living situation, hypertension, diabetes, dyslipidemia, stroke, myocardial infarction or ischemic heart disease, osteoarthritis or rheumatoid arthritis, pulmonary tuberculosis, asthma, renal failure, hepatitis B or C, obesity, and anemia.

b Measured as years per 100,000 person-years.

c Visual impairment was defined as a distance BCVA of worse than 0.5 in the better-seeing eye.

d Obesity was defined as a body mass index of 30 or higher (calculated as weight in kilograms divided by height in meters squared).

e Anemia was defined as a hemoglobin level of less than 13 g/dL in men or less than 12 g/dL in women (to convert to grams per liter, multiply by 10).

Figure 2. Quality-Adjusted Life-year (QALY) Losses and Estimated Preference Weights in the Representative Korean Population With Best-Corrected Visual Acuity (BCVA) Worse Than 0.5

A, Prevalence-based QALY. B, Utility of visual impairment (US definition: a distance BCVA of worse than 0.5 in the better-seeing eye). DL indicates dyslipidemia; DM, diabetes mellitus; HTN, hypertension; MI/IHD, myocardial infarction or ischemic heart disease; OA/RA, osteoarthritis or rheumatoid arthritis; RF, renal failure; Tb, pulmonary tuberculosis; and VI, visual impairment.
Table 2. Preference Weights and Prevalence-Based QALY Losses at BCVA Worse Than 0.32

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Prevalence, Weighted % (SE)</th>
<th>Preference Weight (95% CI)</th>
<th>Annual QALY Loss (%)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual impairmentc</td>
<td>0.45 (0.04)</td>
<td>−0.0870 (−0.1277 to −0.0463)</td>
<td>−38.89 (2.48)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>17.30 (0.32)</td>
<td>−0.0080 (−0.0125 to −0.0034)</td>
<td>−137.92 (8.78)</td>
</tr>
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<td>Diabetes</td>
<td>6.38 (0.17)</td>
<td>−0.0132 (−0.0210 to −0.0054)</td>
<td>−64.14 (5.36)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>8.18 (0.19)</td>
<td>−0.0030 (−0.0094 to 0.0033)</td>
<td>−24.95 (1.59)</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.39 (0.07)</td>
<td>−0.0666 (−0.0852 to −0.0479)</td>
<td>−92.28 (5.88)</td>
</tr>
<tr>
<td>MI or IHD</td>
<td>1.98 (0.09)</td>
<td>−0.0216 (−0.0333 to −0.0479)</td>
<td>−42.82 (2.73)</td>
</tr>
<tr>
<td>OA or RA</td>
<td>12.49 (0.25)</td>
<td>−0.0690 (−0.0750 to −0.0631)</td>
<td>−862.30 (54.91)</td>
</tr>
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<td>Pulmonary Tb</td>
<td>5.08 (0.16)</td>
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<tr>
<td>Obesityd</td>
<td>4.28 (0.16)</td>
<td>−0.0098 (−0.0174 to −0.0022)</td>
<td>−41.92 (2.67)</td>
</tr>
<tr>
<td>Anemia*</td>
<td>8.14 (0.20)</td>
<td>−0.0135 (−0.0194 to −0.0075)</td>
<td>−109.73 (6.99)</td>
</tr>
</tbody>
</table>

Abbreviations: BCVA, best-corrected visual acuity; IHD, ischemic heart disease; MI, myocardial infarction; OA, osteoarthritis; QALY, quality-adjusted life-year; RA, rheumatoid arthritis; Tb, tuberculosis.

*Prevalence estimates were derived from all 29 639 participants 19 years or older. Adjustment factors were age, smoking status, household income, education, residence, occupation and living situation, hypertension, diabetes, dyslipidemia, stroke, myocardial infarction or ischemic heart disease, osteoarthritis or rheumatoid arthritis, pulmonary tuberculosis, asthma, renal failure, hepatitis B or C, obesity, and anemia.

bMeasured as years per 100 000 person-years.

cAnemia was defined as a hemoglobin level of less than 13 g/dL in men or less than 12 g/dL in women (to convert to grams per liter, multiply by 10).

dObesity was defined as a body mass index of 30 or higher (calculated as weight in kilograms divided by height in meters squared).

95% CI, −0.0852 to −0.0479). However, despite the high preference weight, the estimated QALY loss from VI decreased to −38.89 years per 100 000 person-years with decreasing estimated VI prevalence. Detailed estimated preference weights and annual QALY losses from each condition in the sensitivity analyses are provided in Table 2 and Figure 3. The results of sensitivity analyses estimated in participants 40 years or older are provided in eTable 4 in the Supplement and those estimated in participants 60 years or older in eTable 5 in the Supplement.

Discussion

The present study provides a national description of preference weights for VI and 12 chronic health conditions, as well as the corresponding estimated prevalence-based QALY losses, in a large, representative general population of 29,639 participants. Using the KNHANES database, we were able to include in the analyses most chronic health conditions that might have substantial effects on health-related quality of life and/or be quite prevalent in general populations. The estimated preference weights represent an individuals’ burden from a certain chronic condition and preference weights are a key outcome measure when estimating cost-effectiveness or when making decisions regarding drug access.13

The data regarding the preference weight for VI are sparse, especially in the case of uncorrectable VI based on comprehensive measurement of BCVA in a general population; the present study may help to overcome the seeming reluctance to investigate VI-related cost-effectiveness. In the present study, the estimated preference weight for VI was the third highest among those for 13 conditions, and it was more than twice as high as the fourth highest preference weight. When the World Health Organization VI definition was applied, the preference weight for VI was the highest among those for 13 conditions. These results indicate that VI affects individuals’ health-related quality of life much more severely in comparison with other major chronic conditions. In addition, using nationally representative prevalence estimates combined with the QALY model, we could compare the public health burden of VI with that of each of the 12 conditions in a general population.

Although the prevalence of VI was relatively low—the estimated burden associated with VI was comparable to that of diabetes and stroke and higher than those of MI/IHD, obesity, and dyslipidemia. In addition, the proportion of total estimated QALY loss that was accounted for in the general population 19 years or older was similar to that in aged populations; these results underscore VI as a crucial issue for all ages and suggest that health authorities should consider VI more carefully.

Historically, the public health burden of VI has been as high as that of other major chronic health conditions, and this is corroborated by the present findings. In a US study13 using the International Classification of Diseases, Ninth Revision (ICD-9), the preference weight (disutility) of VI was similar to that of stroke and obesity, and higher than that of hypertension, diabetes, dyslipidemia, MI/IHD, asthma, and anemia. A similar study15 from the United Kingdom also showed that the preference weight of VI was similar to those of diabetes and obesity and higher than those of hypertension, dyslipidemia, asthma, and anemia, although stroke and arthritic conditions had higher preference weights than VI. These large studies (38 768 and 79 522 participants aged ≥18 years in the US and UK studies, respectively) were...
further confirmed in the present investigation, even though they defined VI using only the ICD-9 diagnostic code.

A recent study from Singapore involving 3 ethnic cohorts also showed that the preference weight of VI was markedly higher than those of another 4 chronic conditions (obesity, hypertension, diabetes, and hyperlipidemia); furthermore, the estimated QALY loss from VI was higher. This finding was true in all 3 cohorts (3353 Chinese, 3394 Indian, and 3259 Malays). Although the Singapore study included a relatively small number of participants and analyzed only 4 chronic conditions other than VI, it also underscored the importance of VI in public health, as well as the effect of VI on individuals.

A Dutch study that used the disability-adjusted life-years model also reported that the burden of VI ranked fourth—after ischemic heart disease, anxiety disorders, and cerebrovascular disease—among 48 diseases defined by the ICD-9 diagnostic codes. In the same study, disability-adjusted life-years were estimated from data on both mortality and morbidity; when the disability-adjusted life-years estimation was made using only data on morbidity, VI ranked second among 45 diseases in the Netherlands.

Unlike these previous studies, the present study analyzed a government-led, nationwide survey that included a large number of representative participants and a comprehensive health interview and examination. This design resulted in low rates of missing data in the analyses, as well as accurate VI definition using BCVA that had been measured by trained ophthalmologists, is the major strength of the present study. Another strength of the present study is that the EQ-5D index was derived using the South Korean version of preference weights, which differ across countries and cultural backgrounds.

The present study has several limitations. First, the KNHANES did not include institutionalized individuals in whom VI and chronic health conditions are prevalent, and we excluded participants without VA or EQ-5D results. Therefore, the results might not be relevant to hospitalized or institutionalized individuals. The applicability of the preference weights and estimated QALY losses to other races and countries might also be limited, given that we included only Koreans living in South Korea. Another limitation is that the EQ-5D index scores had strong ceiling effects in the present study, as in previous studies. This limitation suggests that EQ-5D might not properly capture the impact of each chronic condition. Moreover, chronic health conditions were defined using the Health Interview Survey, whereby the number of cases of each condition may have been underestimated. Finally, the regression model did not include interaction terms, since we aimed to provide marginal inference regarding the preference weight in the overall population. In addition, it has been reported that the interaction terms were not statistically significant, except for that of OA/RA and VI, when VI was defined as a distance BCVA of worse than 0.5 in the better-seeing eye.

Figure 3. Quality-Adjusted Life-year (QALY) Losses and Estimated Preference Weights in the Representative Korean Population With Best-Corrected Visual Acuity (BCVA) Worse Than 0.32

A, Prevalence-based QALY. B, Utility of visual impairment (World Health Organization definition: a distance BCVA of worse than 0.32 in the better-seeing eye). DL indicates dyslipidemia; DM, diabetes mellitus; HTN, hypertension; MI/IHD, myocardial infarction or ischemic heart disease; OA/RA, osteoarthritis or rheumatoid arthritis; RF, renal failure; Tb, pulmonary tuberculosis; and VI, visual impairment.
Conclusions

The present study provides a national description of preference weights for VI and chronic health conditions; this description might be helpful in future cost-effectiveness studies. In addition, the findings show that the public health burden due to VI is substantial and comparable to that of other major diseases. Although details might vary across populations having different cultural and socioeconomic backgrounds, the results underscore the impact of VI in public health, as well as in individuals, suggesting that public health policies should give more consideration to VI.

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Study concept and design: S. J. Park, Ahn.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: S. J. Park, Ahn.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: S. J. Park, Ahn.

Obtained funding: S. J. Park.

Administrative, technical, or material support: S. J. Park, K. H. Park.

Study supervision: Ahn, K. H. Park.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

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REFERENCES


