Characteristics of Rib Cartilage Calcification in Asian Patients

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IMPORTANT. Rib cartilage from the sixth, seventh, and eighth ribs offers a long cartilaginous curvature, making the material reliable for grafting. Calcification of cartilage causes unexpected absorption, difficult manipulation, and donor site morbidity. Most studies of calcification were performed in Western countries.

OBJECTIVE. To investigate the incidence, degree, and pattern of rib cartilage calcification in Asian patients.

DESIGN, SETTING, AND PARTICIPANTS. Retrospective study of computed tomographic scans of the chest in 120 patients (60 male and 60 female). The incidence, degree, and pattern of cartilage calcification of the sixth through eighth ribs were noted. The patients were stratified into 6 age groups, and 20 patients (10 male and 10 female) were selected for each group. The degree of calcification was assessed as 0%, 1% to 25%, 26% to 50%, 51% to 75%, and 76% to 100%. Meaningful calcification was defined as 26% or greater. The pattern of calcification was classified as marginal, granular, and central.

EXPOSURE. Computed tomographic scans of the chest.

MAIN OUTCOMES AND MEASURES. Degree of calcification, presence of meaningful calcification, and calcification pattern.

RESULTS. Overall, 50.8% of cartilage was calcified, and female patients showed more frequent calcification than male patients (59.4% vs 42.2% [P < .001]). Calcification rates of the sixth and seventh rib cartilage were higher than those of the eighth rib cartilage in all age groups except teenagers, who had a similar rate for all 3 ribs. Calcification of the sixth and seventh rib cartilage significantly increased with age. A meaningful calcification rate was very low in males younger than 60 years, whereas the rate was relatively higher in females than males for all age groups. Males predominantly had the marginal type of calcification, whereas females predominantly had a granular type. The rate and pattern of calcification had no relationship to age.

CONCLUSIONS AND RELEVANCE. In Asian patients, males younger than 60 years show a very low incidence of calcification, whereas females 30 years or older show a relatively high incidence of meaningful calcification. Asian females also show a predominantly granular or central pattern of calcification that may hinder proper harvest and incision of the rib cartilage. These differences in the incidence and pattern of rib cartilage calcification need appropriate preoperative attention.

LEVEL OF EVIDENCE. NA
Autogenous cartilage is widely considered an ideal grafting material for nasal surgery.\(^1\) Septal and conchal cartilages are good graft sources for septorhinoplasty; however, a sufficient amount of this cartilage may not be available in cases of severe deformity requiring extensive reconstruction. Rib cartilage could provide an abundant source of cartilage for graft fabrication and is the most reliable material when structural support is needed.\(^2\)\(^,\)\(^3\) In general, cartilage from the sixth, seventh, or eighth rib is most often harvested because of its long cartilaginous curvature.\(^4\) In addition, the surgeon can incorporate some parts of the synchondrosis of the sixth through eighth rib cartilages.\(^5\)

The major concern about the harvest and incision of rib cartilage in rhinoplasty regards cartilage calcification. Calcification causes unexpected absorption and difficult manipulation, resulting in poor surgical outcomes. In addition, the risk of donor site morbidity, including pneumothorax, may increase if the rib cartilage is calcified.\(^6\) Therefore, preoperative evaluation for rib cartilage calcification characteristics would avoid inappropriate procedures and facilitate an appropriate decision. To date, only a few studies have provided information on the characteristics of rib cartilage calcification. However, most studies\(^7\)\(^\text{-}\)\(^9\) did not evaluate cartilage for rhinoplasty and were forensic studies in Western countries. Our objective was to analyze the incidence, degree, and patterns of rib cartilage calcification of an Asian population using computed tomographic (CT) scans of the chest.

**Methods**

**Patients**

We acquired CT scans of the chest from 3652 patients (age range, 10-69 years) from the Department of Radiology, Seoul National University Borame Medical Center. All patients underwent multilayer CT scanning (Brilliance 16 and Tomoscan AV; Philips) that was not indicated for the purpose of this study. We excluded from this study CT scans of 1342 patients who had bony, cartilaginous, malignant, autoimmune, or rheumatic diseases; posttraumatic stages; or immunodepression. The remaining 2310 patients were stratified by decade of age (10-19, 20-29, 30-39, 40-49, 50-59, and 60-69 years). Twenty patients (10 male and 10 female) were selected by the order of patient identification number in each age group, thus selecting a total of 120 patients (60 male and 60 female). We analyzed 720 rib cartilages consisting of the right and left sides of the sixth, seventh, and eighth rib cartilage of each patient. This study was approved by the institutional review board of Seoul.
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Figure 3. Calcification Rates of the Sixth, Seventh, and Eighth Rib Cartilages

In both sexes, the eighth rib cartilage had the lowest rate of calcification, whereas the calcification rates of the sixth and seventh rib cartilages were similar (sixth and seventh ribs vs eighth rib: \( P < .001 \) and \( P = .001 \) for male and female patients, respectively).

Figure 4. Age-Specific Calcification Rates of the Sixth, Seventh, and Eighth Rib Cartilages

A significant increase in calcification of the sixth (\( P < .001 \)) and the seventh rib cartilages (\( P = .01 \)) was found with age. This process was not verified for the eighth rib cartilage (\( P = .34 \)).

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Evaluation of the Degree and Pattern of Calcification

Coronal CT scans with 3-mm thickness were used to measure the degree and pattern of rib cartilage calcification. We distinguished the following 5 grades to classify the variable degree of calcification: 0 (0%), 1 (1%-25%), 2 (26%-50%), 3 (51%-75%), and 4 (75%-100%) (Figure 1). The degree of calcification was measured from the entire rib cartilage, including the shorter lateral part and longer medial part. Among the 5 grades, calcification of grades 2 to 4 was considered meaningful.

The calcification patterns were classified as marginal, granular, and central types by the position of calcification as adopted from previous studies (Figure 2).\(^{10,11}\) A granular type was defined as those calcifications that occurred at multiple spots. All radiologic measures were made by a single investigator blinded to the study groups (W.S.S.). We used commercially available software (M-view, version 5.4; Marotec Medical System) for radiologic measures. The proportion of calcification was measured automatically with this software by outlining the calcification area and cartilage area of each CT section manually. We used the bone window setting of this program to evaluate the presence and the extent of calcifications. Window level was 500 Hounsfield units (H) and window width was 3000 H in this setting.

Statistical Analysis

Linear-by-linear association was used to analyze the incidence and pattern of calcification according to age and sex. The relationship between sex and calcification degree was calculated with a \( \chi^2 \) test. Statistical significance was assumed at \( P < .05 \) for all variables. All statistical analyses were performed with commercially available software (SPSS, version 20.0; SPSS Inc).

Results

Calcification Rate

As a whole, rib cartilage was calcified in 366 of 720 CT scans (50.8%). Female patients showed more frequent calcification than male patients (59.4% vs 42.2% \( [P < .001] \)), especially in the eighth rib. In both sexes, the eighth rib cartilage had the lowest rate of calcification, whereas the calcification rates of the sixth and seventh rib cartilages were similar (Figure 3). Calcification rates of the sixth and seventh rib cartilages were higher than that of the eighth rib cartilage in all age groups (\( P < .05 \) for each group) except for the youngest group, which had a similar rate (\( P = .52 \)). Calcification of the sixth (\( P < .001 \)) and seventh (\( P = .01 \)) rib cartilages increased significantly with age. However, this process was not verified for the eighth rib cartilage (\( P = .14 \)) (Figure 4). We found no difference in calcification rate between the right and left sides (\( P = .50 \)).

Rate of Meaningful Calcification

Meaningful calcification (grades 2-4) was observed even in teenagers, and overall occurred in 77 of 720 CT scans (10.7%). The rate was higher in female than in male patients (62 of 360 [17.2%] vs 15 of 360 [4.2%] \( [P < .001] \)), but all 3 cartilages had similar rates of meaningful calcification in both sexes (Figure 5). The meaningful calcification rate increased significantly with age in the sixth and seventh rib cartilages (\( P < .05 \)), but not in the eighth rib cartilage (\( P > .05 \)). The rate for males 60 years or older was higher than that for males younger than 60 years (\( P < .001 \)), whereas females had no difference among age groups (\( P = .28 \)). We found no different in the rate between the right side and sides (\( P = .90 \)).

Patterns of Rib Cartilage Calcification

Male patients predominantly showed a marginal type of calcification (78.9%), whereas female patients predominantly had a granular type (49.0%). The central type appeared more frequently in female than male patients (16.2% vs 4.6% \( [P < .001] \))
(Figure 6). The pattern of calcification had no relationship with age or the side of the cartilage.

Discussion

Rib cartilage calcification has been known to increase with age, and a relationship with sex has been reported. In general, old age is considered a contraindication for rib cartilage harvest owing to an undesirable degree of calcification. In our study, although the teenage group had a lower calcification rate than other age groups in the sixth and seventh rib cartilages, which is in agreement with other reports, the rate was similar among all other age groups. This finding indicates that increasing age alone is not a contraindication for rib cartilage harvest. In a noteworthy finding, 22.5% of teenage female patients showed calcification, as early as 14 years old in some. This finding suggests that onset of rib cartilage calcification is earlier in women than in men.

Not all types of calcifications are considered contraindications for cartilage harvest. A mild degree of calcification grade (<2) does not hinder harvest or incision of cartilage, whereas meaningful (moderate to severe) calcification does. In our study, female patients showed a higher incidence of calcification and a higher incidence of meaningful calcification compared with male patients. In contrast to males who showed a very low incidence of calcification at younger than 60 years, females showed a relatively high incidence (>13%) of meaningful calcification at 30 years and older. This finding implies that even girls and young women need attention regarding the possibility of meaningful calcification that hinders rib cartilage use for grafting purposes. Thus, preoperative assessment of the calcification degree is necessary, by obtaining a series of radiographs of the rib or by pricking the rib cartilage with a fine needle to assess hardness after local anesthesia.

The seventh rib cartilage has been known as the safest anatomically because it is situated over the abdominal cavity; thus, the chance of pneumothorax is insignificant and injury of the internal thoracic artery and vein injury is not common. Because no difference is seen in the meaningful calcification rate between the seventh and eighth rib cartilages, the seventh rib cartilage could be a better choice because it provides more safety and a longer straight cartilage segment.

Similar to previous reports from Western countries, the present study showed that the marginal pattern was more common in males and the central pattern was more common in females. The fact that female patients had a granular pattern more often than a central pattern differs from reports of Western countries but is consistent with a report from Japan, which indicates an ethnic difference in the calcification pattern of rib cartilage. The exact cause of ethnic differences is unclear, although hormonal levels and growth patterns are presumed to be involved. Cartilage with marginal calcification may cause some difficulties in harvesting, but the central portion can be used safely. On the other hand, a central or granular pattern of calcification makes the cartilage difficult to harvest for many purposes. In our study, females showed not only a high incidence of meaningful calcification, but also a high incidence of granular and central patterns of calcification that makes use of rib cartilage difficult.

The side used for rib cartilage harvest depends on the surgeon's preference. Most right-handed surgeons prefer to harvest rib cartilage on the right side because this side is the surgeon's position. In addition, harvesting from the left side may result in tearing of the pleura or pericardium, and pain on the left side of the chest can be confused with cardiac pain. Because no differences in sides were found in our results for rib cartilage calcification, this study supports the idea that the choice of harvest side depends purely on the surgeon's preference.

In conclusion, in Asian patients, males show a very low incidence of calcification at younger than 60 years, whereas fe-
males show a relatively high incidence of meaningful calcification at 30 years or older. Asian female patients show a predominantly granular or central pattern of calcification that may hinder proper harvest and incision of rib cartilage. These differences in the incidence and pattern of calcification of rib cartilage need appropriate preoperative attention.

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