Quantification of Bending Tolerance of the Cartilaginous Nasal Septum: Computer-Based Measurements

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ABSTRACT

Objective: Nose deformity, including nasal deviation, is conspicuous since it locates in central face area. Regarding this and its prevention, nasal septum is one of the important supporting structures. Understand bending tolerance of the cartilaginous septum not only helps mitigate secondary deformity from surgical intervention, but also provides baseline information for further study regarding the nasal septum.

Materials and Methods: Nineteen fresh cadavers were dissected to expose the cartilaginous nasal septum. It was connected with the set-up computer system for detection of electrical signal at 1-mm septal bending from the midline. Mechanical load (bending load) was applied over the dorsal septum to quantify its bending tolerance. The data of bending tolerance and Pearson's correlation were reported.

Results: The mean of septal thicknesses is 1.5 ± 0.4 with the average bending load of 19.0 ± 11.2 g. The majority of the septal thicknesses (15/19; 78.9%) of the dissections are within the range of 1.1 – 2.0 mm with bending load of 18.2 ± 8.9 g on average. There is a moderately positive association between septal thickness and bending load, the Pearson's correlation coefficient is 0.602 (95%CI from 0.204 to 0.830) with p-value of 0.006.

Conclusion: The overall nasal septum and the septum with thickness between 1.1 – 2 mm are able to tolerate loading over distal part of caudal septum about 19.0 and 18.2 g, respectively. Septal thickness shows moderately positive correlation with bending load.

Keywords: Nasal septum; nasal deformity; bending tolerance; mechanical load; quantification (Siriraj Med J 2022; 74: 425-430)

INTRODUCTION

Nose is one of the central face structures, so any nasal deformity is conspicuous.[1] In current era, there are many nasal procedures for aesthetic and functional purposes. The majority of them, such as nasal tip augentation, increase mechanical load to the nasal septum and other midline supports. These procedures therefore require sufficiently strong support to maintain the structures in the midline. Improving nasal stability in weak septum is possible, but its drawbacks are longer operative time and

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more procedure complexity.[2-5] Understanding baseline strength of the septum to tolerate the mechanical load is beneficial especially in Asian population, whom commonly undergo augentation nasal tip procedure. As far as we know, there is no study regarding bending tolerance of septal cartilage to mechanical load. This study is therefore conducted to clarify this aspect in Asian population.

MATERIALS AND METHODS

Nineteen fresh cadavers without history of nasal dissection or pre-existing weakness of nasal septum detected by palpation before experimental processes were included in this study. These included 12 males and 7 females within the age of 16 – 97 years. This study was approved by the ethical committee of the Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand.

Skin envelope, lower lateral cartilage, and upper lateral cartilage were dissected to expose the midline bony-cartilaginous framework of the nose. Parameters of the nasal septum, including thickness, length of caudal septum, and length of dorsal septum, were recorded. The thickness of caudal septum was measured at midpoint between anterior nasal spine (ANS) to anterior septal angle (ASA). Lengths of dorsal side and caudal side of the septum are defined as the distance from rhinion to ASA and from ANS to ASA, respectively. Surrounding soft tissue was removed as needed to facilitate setting up of the instruments for measurement in later process.

Two force transducers connected to nasal septum using non-elastic thread. Another end of each transducer connected to bridge amplifier, which subsequently connected to MacLab, an Analog-to-digital converter, that connected to the computer. This system with Chart 5 software (AdInstruments, Dunedin, New Zealand) convert mechanical load into electrical signal. The third force transducer was set over the septal area to apply mechanical load (unit of gram). This load created bending of the nasal septum, observed on the caudal view (Fig 1). The overall system is shown in Fig 2. For consistent results and measurements, additional test was done repeatedly before the main experiment. This showed that any mechanical load applied over the dorsal septum generated electrical signal of +/-0.1 mV from either arm of force transducers is consistent with septal bending of 1 mm from the midline. This mechanical load is defined as "bending load". In each cadaver, the bending load was quantified 3 times in each cadaver to find average for statistical analyses.

Statistical analyses

Mean with standard deviation (SD) and median with interquartile range (IQR) will be used for descriptive statistics. To determine magnitude of association between two variables, we used use Pearson's correlation coefficient with 95% confidence intervals (95%CI) calculated by using Fisher's z transformation due to rather normal distribution of the data, but will interpret along with rank correlation coefficients; Spearman's and Kendall's tau-b. The level of significance is set at 0.05 for all statistical testing.

RESULTS

There were 19 cadaveric subjects in this observational study with 12 males (63.16%) and the average age of 73.84 years (SD 10.68, median 72, IQR 9). Thickness of nasal septum, length of dorsal septum, and length of caudal septum were within range of 0.7 – 2.2 mm, 1.7 – 2.7 cm, and 1.5 – 2.6 cm, respectively. There was

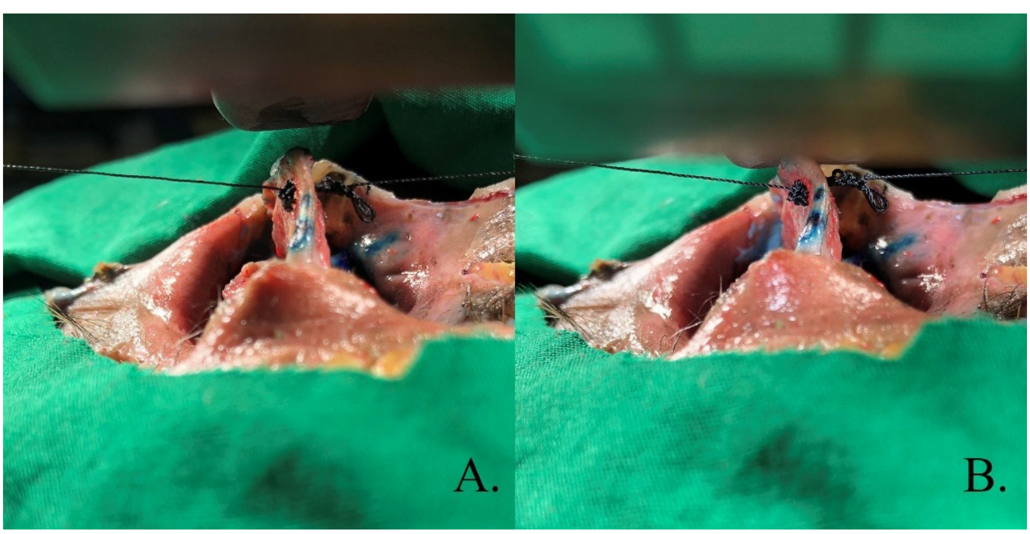

Fig 1. Bended nasal septum (1 mm from the midline), observed on the caudal view.

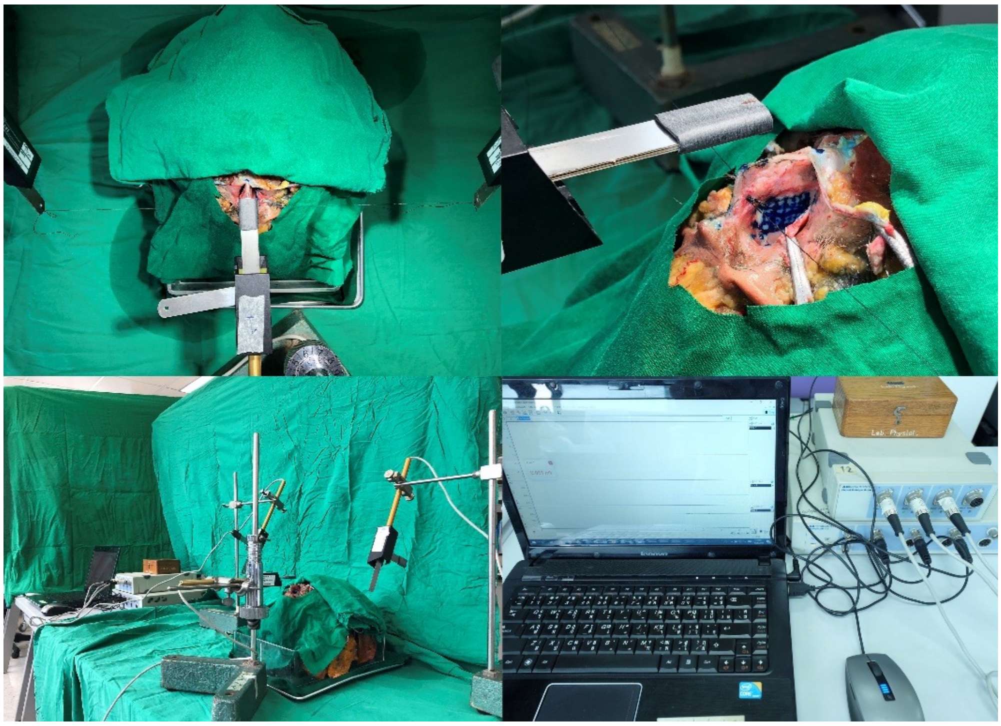

Fig 2. The overall system.

no correlation between lengths of dorsal septum and caudal septum (correlation coefficient of -0.014, p-value 0.953). The majority of the thickness (15/19; 78.9%) of the dissections were within the range of 1.1 – 2.0 mm (Table 1).

Overall, average mechanical load creating bending nasal septum of 1 mm was 19.0 ± 11.2 g. This average of the load was 18.2 ± 8.9 g in the group with thickness between 1.1 – 2.0 g. The average loads related to subgroups of thickness are shown in Table 1.

Correlations between bending loads and parameters of nasal septum, including thickness, length of dorsal septum, and length of caudal septum, are shown in Figs 3, 4, and 5, respectively. The bending load showed moderately positive association with septal thickness, Pearson's correlation coefficient is 0.602 (95%CI from 0.204 to 0.830) with p-value of 0.006 corresponding with rank correlation coefficients of 0.562 for Spearman's and of 0.467 for Kendall's with p-value of 0.012 and 0.007, respectively. The length of dorsal septum was moderately correlated with the bending load with statistical significance (coefficient of 0.564, p-value = 0.012), but the rank correlation coefficients showed no significance (Spearman's of 0.402 with p-value = 0.088 and Kendall's of 0.322 with p-value = 0.073).

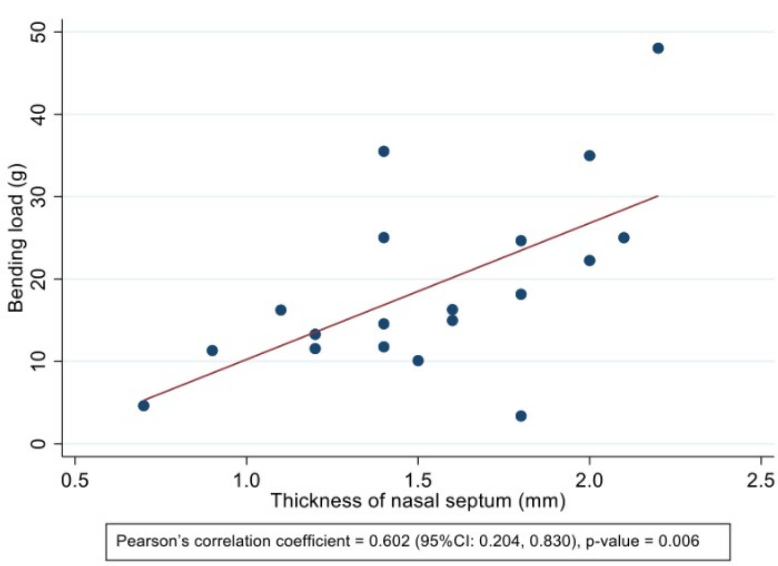

Fig 3. Pearson's correlation between bending load and thickness of nasal septum.

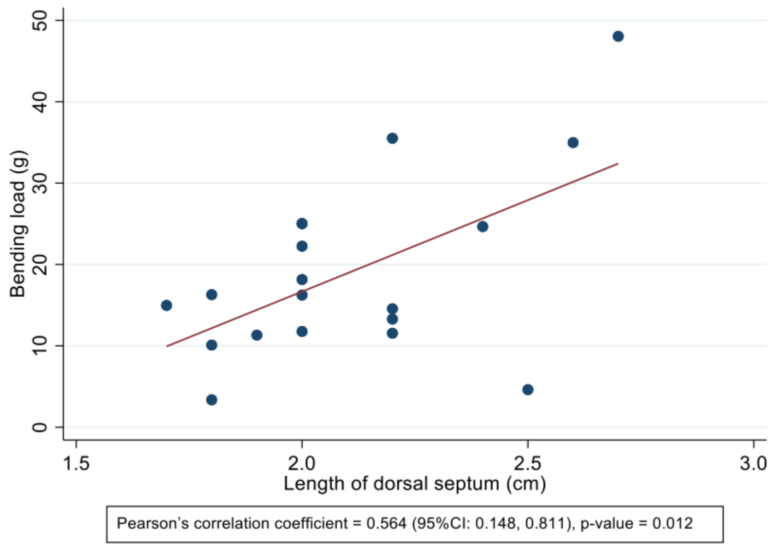

Fig 4. Pearson's correlation between bending load and length of dorsal septum.

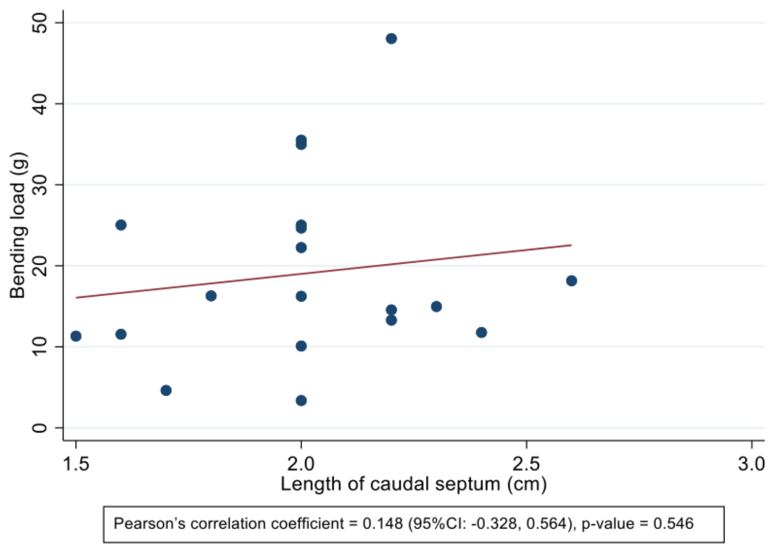

Fig 5. Pearson's correlation between bending load and length of caudal septum.

TABLE 1. Average of bending load by subgroups of septal thickness.

Septal thickness	n (%)	Bending load (g)	
		Mean (SD)	Median (IQR)
Overall	19 (100.0)	19.0 (11.2)	16.2 (13.5)
Subgroups			
1.1 to 2.0 mm (majority)	15 (78.9)	18.2 (8.9)	16.2 (12.9)
1 mm or less	2 (10.5)	8.0 (4.7)	8.0 (6.7)
1.1 to 1.5 mm	8 (42.1)	17.3 (8.7)	13.9 (9.0)
1.6 to 2.0 mm	7 (36.9)	19.2 (9.7)	18.2 (9.7)
2.1 mm or more	2 (10.5)	36.5 (16.3)	36.5 (23.0)
1.5 mm or less	10 (52.6)	15.4 (8.8)	12.5 (4.9)
1.6 mm or more	9 (47.4)	23.1 (12.7)	22.3 (8.7)

DISCUSSION

Nose is a crucial organ as it is a part of the upper respiratory system. In addition to this function, the nose also serves as an aesthetic structure of the face due to its location within central face area.[1] This comes with the concern that any nasal deformity is commonly noticeable. Anatomically, the nose consists of nasal skin envelope and osteocartilaginous framework. The framework is the foundation of the nose. There are 3 pairs and 3 midline structures. The former are nasal bones, upper lateral cartilages, and lower lateral cartilages. The midline structures are cartilaginous nasal septum, perpendicular plate of ethmoid bone, and vomer. Among these midline structures, surgical application is frequently focused on the nasal septum since its common deformity and capability to serve as cartilage donor.[6,7] Understanding anatomy of the septal cartilage is therefore crucial for surgical application to minimize the complications.

Septoplasty is one of the most commonly performed procedures. Each surgery comes with possible complications and the most commonly cited ones are saddle nose deformity and supratip depression.[8-10] These results from weakness of septal cartilage. To reduce these complications, it has been recommended to leave width of the septal L-strut of more than 10-15 mm.[9-13] In some cases, additional procedures of septal modification are required to strengthen the weak septum.[2-5] In severe scenarios of septal deformity, total reconstruction of the septum (extracorporeal septal reconstruction) is needed.[14-16] These 2 main operations share common principle of providing strong support to create a good foundation for the nose. However, powerful support comes at the exchange stiff nose appearance due to loss to pliability of the distal nose.[17] Balance between these 2 ends are crucial to provide aesthetically strong nose.

In this study, we quantify bending load to the nasal septum, one of the supporting midline nasal structures. Overall, nasal septum can tolerate force applied over its distal part of dorsal side approximately 19.0 g. This parameter can be applied as a baseline value of nasal septum in future studies to mimic native septum providing sufficiently strong support and aesthetic pliability. In addition, there is moderate correlation between the thickness and bending load with statistical significance. This is also helpful in application for septal reconstruction by increasing thickness of the septum to provide better support. This bending load varies by dividing thickness subgroups. In clinical practice, the difference of 1.9 g of bending loads between the thickness of 1.1 – 1.5 mm (17.3 g) and 1.6 – 2 mm (19.2 g) seems to be not significant. On the other hand, bending loads in septal thickness of 1 mm or less and 2.1 mm or more tend to show clinically significant difference, but their statistical differences require additional study with larger sample size. Average bending load of 36.5 g in thickness of more than 2.1 mm is comparable to one study reported nasal tip support in Caucasian population.[18] Although the research methodology is different, this number is worth mentioned due to probability that septal thickness of more than 2 mm able to tolerate bending load of more than 30 g on average. This finding assertively supports the positive correlation between the thickness and bending load.

The clinical implication of the findings in this study should be customization of the material using in nasal reconstruction to achieve comparable strength to native septal cartilage for aesthetically durable framework without stiff nose appearance. In addition, the bending load reported in our study can be applied in simulation of further nasal septum studies. However, larger sample size is required to quantify the average bending load in the population with septal thickness of less than 1 mm and more than 2 mm for clinical implication, and to possibly find the explanation of correlation between dorsal septum and bending load.

In case of septal deviation, findings from previous study[19] revealed the statistically significant decrease in air flow and increase in resistance of the nasal cavity ipsilateral to the deviating direction of the septum therefore this deviated septum, especially in the severe cases, seems to require surgical intervention for relieving its clinical symptom caused by such structural drawbacks. Nonetheless, further study on the load-bearing strength of septum with varying degree of deviation and thickness before and after L-strut septoplasty would be necessary for application in weighing the clinical advantage in each patient case prior to decision for operational correction.

CONCLUSION

Septal thickness shows moderately positive correlation with bending load. The nasal septum and the septum with thickness between 1.1 – 2 mm are able to tolerate loading over distal part of caudal septum about 19.0 and 18.2 g, respectively.

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