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# Complications of Nasopharyngeal Swabs and Safe Procedures for COVID-19 Testing Based on Anatomical Knowledge

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## ABSTRACT

Nasopharyngeal swabs have been widely used to prevent the spread of coronavirus disease 2019 (COVID-19). Nasopharyngeal COVID-19 testing is a generally safe and well-tolerated procedure, but numerous complications have been reported in the media. Therefore, the present study aimed to review and document adverse events and suggest procedural references to minimize preventable but often underestimated risks. A total of 27 articles were selected for the review of 842 related documents in PubMed, Embase, and KoreaMed. The complications related to nasopharyngeal COVID-19 testing were reported to be rarely happened, ranging from 0.0012 to 0.026%. Frequently documented adverse events were retained swabs, epistaxis, and cerebrospinal fluid leakage, often associated with high-risk factors, including severe septal deviations, pre-existing skull base defects, and previous sinus or transsphenoidal pituitary surgery. Appropriate techniques based on sufficient anatomical knowledge are mandatory for clinicians to perform nasopharyngeal COVID-19 testing. The nasal floor can be predicted by the line between the nostril and external ear canal. For safe testing, the angle of swab insertion in the nasal passage should remain within 30° of the nasal floor. The swab was gently inserted along the nasal septum just above the nasal floor to the nasopharynx and remained on the nasopharynx for several seconds before removal. Forceful insertion should be attempted, and alternative examinations should be considered, especially in vulnerable patients. In conclusion, patients and clinicians should be aware of rare but possible complications and associated high-risk factors. The suggested procedural pearls enable more comfortable and safe nasopharyngeal COVID-19 testing for both clinicians and patients.

**Keywords:** Nasopharyngeal Swab; COVID-19 Testing; Complications; Procedural Reference; Risk Factors

## INTRODUCTION


The nasopharyngeal swab and rapid antigen detection test or reverse transcription-polymerase chain reaction (RT-PCR) have been performed more than average of 600,000 and

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### Disclosure

All authors have no potential conflicts of interest to disclose.

### Author Contributions

Conceptualization: Rhyu IJ. Data curation: Rhyu IJ, Kim DH. Formal analysis: Rhyu IJ, Kim D. Funding acquisition: Rhyu IJ. Investigation: Kim DH, Kim D, Moon JW. Methodology: Rhyu IJ, Chae S, Kim DH. Validation: Rhyu IJ, Chae S, Kim DH. Visualization: Chae S, Moon JW. Writing - original draft: Kim DH. Writing - review & editing: Rhyu IJ, Chae S.

3,000,000 times daily in South Korea<sup>1</sup> and USA,<sup>2</sup> respectively to detect both symptomatic and asymptomatic patients with coronavirus disease 2019 (COVID-19).<sup>3-6</sup> The initial form of swab, Q-tip, was invented by a Polish-American Leo Gerstenzang to clean his child's ears in 1923.<sup>7,8</sup> The swab gained popularity in the 1950s and is still widely being used in various modified forms from cleaning one's ear in daily lives to COVID-19 testing in quarantine facilities.

The trans-nasal approach to obtain the respiratory tract secretions in the nasopharynx has been regarded as the gold standard for optimal specimen collection of COVID-19 testing with RT-PCR.<sup>3,9</sup> The examination can also be performed on the anterior nares, middle turbinate, and nasopharynx, but the sensitivity resulting from the specimen collected on the anterior nares and middle turbinates was significantly inferior compared with the results of the nasopharynx.<sup>3,10</sup> The sensitivity of the rapid antigen detection test using a nasopharyngeal swab was higher than that of the anterior nasal swab often used in the self-performing screening test.<sup>6</sup> Therefore, the robust trend to proceed with extensive nasopharyngeal COVID-19 testing is expected to continue considering the diagnostic accuracy and general perception that it is a safe and well-tolerated procedure.<sup>3,11,12</sup>

However, numerous complications, from minor to even fatal ones, have been repetitively reported in the media<sup>13,14</sup> and literatures<sup>3,11,12,15-36</sup> although complications required further medical evaluation were rarely happened ranging from 0.0012%<sup>24</sup> to 0.026%.<sup>20</sup> In addition, excessive quarantine burden and stressful condition of the COVID-19 pandemic<sup>37,38</sup> occasionally causes uncomfortable testing by the examiner who may not fully understand the nasopharyngeal anatomy or clinically cautious events related to nasopharyngeal swabs.<sup>11,39</sup> In this study, a literature review of adverse events related to nasopharyngeal COVID-19 testing was performed to raise attention about rare but existing risks. Moreover, authors suggested the procedural references based on nasopharyngeal anatomy for more comfortable and safe nasopharyngeal COVID-19 testing.

## COMPLICATIONS RELATED WITH NASOPHARYNGEAL COVID-19 TESTING

### Data searches

The PubMed and Embase databases were searched for articles published between 2019 and 2022. KoreaMed was explored between 2010 and 2022 due to the relative shortage of products in the pilot search. The searched keywords included "nasopharyngeal swab," "nasopharynx swab," "nasal swab," "pernasal swab," "rhinopharyngeal swab," "pharyngeal swab," "nasopharyngeal test," "swab stick," "swabbing test," "complications," "safe," "safety," "COVID," "severe acute respiratory syndrome," "coronavirus," "2019nCoV," "nCoV2019" or "HCoV-19," and "NCOVID-19". The literature search focused on human studies and excluded animal experiments. Articles written in English or Korean were included in the database.

### Study selection, data extraction, and assessment

A total of 314, 774, and 29 articles were extracted from the initial search through PubMed, Embase, and KoreaMed databases, respectively. After removing duplicate cases, 842 articles remained. The first author fully screened all abstracts and titles of the results to identify articles related to complications due to nasopharyngeal COVID-19 testing. Finally, 27 articles were selected for review.<sup>3,11,12,15-36,40,41</sup>

### Documented complications associated with nasopharyngeal COVID-19 testing

All the researched complications due to nasopharyngeal COVID-19 testing were classified, and the related information is shown (Table 1). Retained swabs<sup>3,12,16-18,20,21,24,26,27,32,35</sup> due to swab fracture during the examination and epistaxis<sup>3,12,17,24,28,32</sup> were the frequently reported complications. Cerebrospinal fluid (CSF) leakage<sup>3,11,12,15,22,23,28-30,33,34,36</sup> was a frequently documented serious adverse event requiring prompt attention and evaluation. Nasal septal abscess,<sup>3,12,17,19,25</sup> and ethmoidal silent syndrome<sup>31</sup> were also reported as related complications after nasopharyngeal swabbing.

**Tables 1.** Summary of previously reported adverse events related to coronavirus disease 2019 nasopharyngeal swab testing

Complications	References	Article type	No. of cases	Combined medical conditions	Evaluation & management
Retained swabs	De Luca et al., 2021 <sup>12,16</sup>	Case report	1	Swallowed swab in stomach	GI endoscopy
	Fabbris et al., 2021 <sup>3,12,17</sup>	Letter to editor	3	Retained in nasal cavity	Removal under endoscopic view
	Farina and Nelson, 2021 <sup>18</sup>	Letter to editor	1	Swallowed swab in duodenum	GI endoscopy
	Föh et al., 2021 <sup>3,12,20</sup>	Letter to editor	2	Retained in nasal cavity, swallowed swab	Nasal endoscopy
	Gaffuri et al., 2021 <sup>3,12,21</sup>	Case report	1	Retained in choanal cavity	Flexible bronchoscopy
	Koskinen et al., 2021 <sup>24</sup>	Research letter	4	Retained in nasal cavity	Nasal endoscopy
	Molnár et al., 2021 <sup>26</sup>	Case report	1	Swallowed swab in stomach	GI endoscopy
	Mughal et al., 2020 <sup>3,12,27</sup>	Case report	1	Retained in nasal cavity	Nasal endoscopy
	Rigante et al., 2021 <sup>32</sup>	Case report	1	Retained behind the septal deviation, epistaxis	Nasal endoscopy, mini-septoplasty, removal of septal spur and swab
	Tümer and Ardiçlı, 2021 <sup>35</sup>	Letter to editor	1	Swallowed swab in duodenum	GI endoscopy
Epistaxis	Fabbris et al., 2021 <sup>3,12,17</sup>	Letter to editor	4	Rupture of a small artery of the olfactory area in one case	Nasal packing or surgical cauterization
	Koskinen et al., 2021 <sup>24</sup>	Research letter	4	Local or systemic infection, septum perforation, scarring	Anterior/posterior nasal packing, bipolar coagulation, anterior ethmoidal artery ligation, sphenopalatine artery embolization, local hemostatic, systemic antibiotics
	Ovenden et al., 2021 <sup>28</sup>	Case report	1	CSF leakage	Nasal endoscopy
CSF leakage	Rigante et al., 2021 <sup>32</sup>	Case report	1	Retained swab behind the underlying septal deviation	Nasal endoscopy, mini-septoplasty, removal of septal spur and swab
	Agamawi et al., 2021 <sup>11</sup>	Case report	1	Sphenoid injury	Endoscopic surgical repair with nasoseptal flap
	Alberola-Amores et al., 2021 <sup>3,12,15</sup>	Letter to editor	1	Cribriform plate injury, meningitis	Systemic antibiotics, corticosteroid
	Holmes and Allen, 2021 <sup>22</sup>	Case report	1	Pre-existing meningocele, cribriform plate injury, meningitis, ventriculitis	Systemic antibiotics, corticosteroid, endoscopic surgical repair, ventriculo-peritoneal shunt placement
	Knížek et al., 2021 <sup>23</sup>	Case report	1	Cribriform plate injury	Endoscopic surgical repair, systemic antibiotics
	Ovenden et al., 2021 <sup>28</sup>	Case report	1	Cribriform plate injury, epistaxis	Nasal endoscopy, conservative management
	Paquin et al., 2021 <sup>12,29</sup>	Case report	1	Pre-existing encephalocele, cribriform plate injury	Endoscopic surgical repair, bipolar cautery and free mucosal graft
	Rajah et al., 2021 <sup>3,12,30</sup>	Case report	1	Pre-existing encephalocele, sphenoid injury	Endoscopic skull base repair, excision of encephalocele
	Samadian et al., 2021 <sup>33</sup>	Case report	1	Cribriform plate injury	Endoscopic surgical repair
	Sullivan et al., 2020 <sup>3,12,34</sup>	Case report	1	Underlying idiopathic intracranial hypertension, pre-existing encephalocele, cribriform plate injury	Endoscopic surgical repair with acellular human dermal matrix, reduction of the encephalocele
Nasal septal or pharyngeal abscess	Yilmaz et al., 2021 <sup>36</sup>	Case report	1	Past history of minor head trauma, cribriform plate injury	Endoscopic surgical repair with nasoseptal flap
	Fabbris et al., 2021 <sup>3,12,17</sup>	Letter to editor	1	Retained swab, epistaxis	Incision and drainage
	Fazekas et al., 2021 <sup>19</sup>	Case report	1	Preseptal cellulitis, infraorbital abscess	Systemic antibiotics, corticosteroid
Ethmoidal silent sinus syndrome	Lapeyre et al., 2021 <sup>25</sup>	Case report	1	Underlying end stage renal disease, mastoiditis, osteitis, sepsis	Systemic antibiotics
	Ribeiro et al., 2022 <sup>31</sup>	Case report	1	Turbinate fracture	Endoscopic surgical repair with partial resection of the left middle turbinate

GI = gastrointestinal, CSF = cerebrospinal fluid.

### Retained swab

Retained swabs after nasopharyngeal COVID-19 testing have been frequently reported in the literature.<sup>3,12,16-18,20,21,24,26,27,32,35</sup> Swabs for COVID-19 examination are intrinsically vulnerable to accidental fragmentation due to an inherent breakpoint mechanism for effective transfer to the transport vial, especially in uncooperative or sedated patients.<sup>12</sup> Moreover, accidental hard contact with nasal anatomical structures, including septal spurs and inferior and middle turbinates, are other risk factors for swab fracture.<sup>12</sup> Therefore, clinicians should remember related anatomical structures and check for the presence of structural anomalies including severe septal deviation before testing. Many cases of the retained swab could be managed with nasal endoscopic removal<sup>17,20,24,27</sup> or sometimes retrieved with a bronchoscope.<sup>21</sup> In addition, the swab fragments could be found in the gastrointestinal (GI) tract such as the stomach<sup>16,26</sup> and duodenum,<sup>18,35</sup> which requires GI endoscopy for retrieval. In one case, a fractured swab was found in the upper part of the nose behind the underlying severe septal deviation and was extracted after mini-septoplasty and septal spur removal.<sup>32</sup> The possibility of foreign body ingestion or aspiration should be carefully inspected if the retained swab is not found in the endoscopic evaluation.<sup>12</sup>

### Epistaxis

Epistaxis is one of the most common adverse events associated with nasopharyngeal COVID-19 testing. A total of sixteen cases of epistaxis were reported as a result of nasopharyngeal swab.<sup>3,12,17,24,28,32</sup> Highly vascular nasal mucosa is prone to mechanical trauma by the swab and bleeding, especially in the circumstances of an inflamed upper respiratory tract in COVID-19 patients, an elderly person who takes anticoagulation medications, or a person with intranasal anatomical variations including septal deviations.<sup>3,12</sup> Most of the cases were self-limiting or could be managed with nasal packing.<sup>3,12,17</sup> However, potentially life threatening bleeds were also reported and additional procedures including bipolar coagulation, artery ligation, and embolization were required for proper hemostasis.<sup>24</sup> The anatomical area of epistaxis often determines the progress because most cases of anterior bleed could be easily managed with firm external nasal pressure; however, posterior bleeds frequently require endoscopic cauterization and packing.<sup>3,17,24</sup> Clinicians should remember to screen risk factors, check the more comfortable side during nasal breathing prior to the procedure, and avoid forceful insertion in the presence of any resistance.<sup>3,17</sup> In the presence of high-risk factors for bleeding, less invasive evaluation should be considered instead of performing a nasopharyngeal swab.<sup>12</sup>

### CSF leakage

The CSF leakage resulting from iatrogenic skull base damage is a potentially fatal adverse event. It is commonly thought to be rare, but severe cases have been reportedly related to nasopharyngeal COVID-19 testing.<sup>11,15,22,23,28-30,33,34,36</sup> Traumatic CSF leakage after nasopharyngeal COVID-19 testing is usually manifested as unilateral clear rhinorrhea, persistent headache, or salty or metallic taste postnasal drip within 48 hours after the procedure.<sup>11,22,29,30,33,34,36</sup> The amount of rhinorrhea tends to increase with bending forward and Valsalva maneuver.<sup>11,22,29,30</sup> The majority of CSF leakage originated from damage in the cribriform plate (**Fig. 1A**),<sup>15,22,23,28,29,33,34,36</sup> and sometimes the sphenoid area.<sup>11,30</sup> A beta-2-transferrin assay with the sample of rhinorrhea can confirm the diagnosis of CSF leakage.<sup>11,15,22,28,30,33,34</sup> A beta-2-transferrin assay is a sensitive and specific diagnostic tool for CSF leakage because it is only found in CSF, perilymph, and vitreous humor.<sup>22</sup> Computed tomography and/or magnetic resonance imaging are required to locate traumatic damage or sometimes pre-existing skull base defects with encephalocele<sup>29,30,34</sup> or meningocele.<sup>22</sup>

Patients who show CSF leakage should remain on strict bed rest, maintain head elevation to 30 degrees, and avoid blowing their nose, coughing, and performing strenuous exercise.<sup>22</sup> CSF leakage can be treated with endoscopic surgical repair in most cases, but further management, including systemic antibiotics and corticosteroids, is required when meningitis is complicated.<sup>3,12,15,22</sup> Clinicians should check for a history of septal deviations, pre-existing skull base defects, previous sinus or trans-sphenoidal pituitary surgery, and other possible concerns for a skull base injury before testing.<sup>3,11,34</sup> After confirmation of the high-risk factors, alternative examinations such as modified nasopharyngeal swab through the trans-oral way or saliva swab should be considered to prevent potentially lethal complications.<sup>3,34,42,43</sup> Clinicians should be educated about appropriate angles and depths of swab insertion before nasopharyngeal COVID-19 testing for safe procedures.

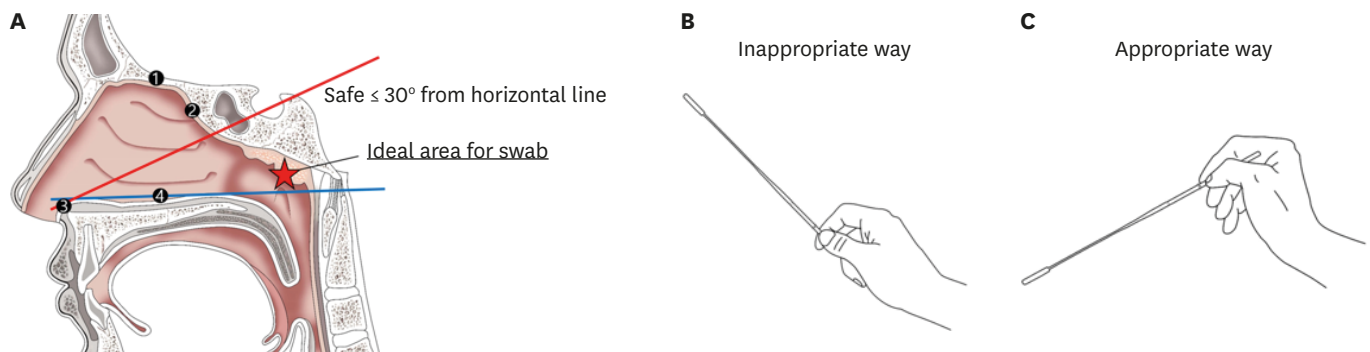
### Other complications

The nasal septal or pharyngeal abscess could be due to nasopharyngeal COVID-19 testing.<sup>3,12,18,19,25</sup> The infectious state could comorbid with cellulitis,<sup>19</sup> mastoiditis, osteitis, and even aggravate to sepsis.<sup>25</sup> The treatment methods were incision and drainage<sup>17</sup> and administration of systemic antibiotics.<sup>19,25</sup> A single case of ethmoidal silent sinus syndrome was also documented after nasopharyngeal swab.<sup>31</sup> Silent sinus syndrome is manifested as orbital floor depression, enophthalmos, hypoglobus, enlargement of middle nasal meatus, and facial asymmetry due to maxillary sinus atelectasis as a result of chronic obstruction of the sinus drainage.<sup>31</sup> The traumatic etiology of silent sinus has been rarely documented.<sup>31,44</sup>

## PROCEDURAL REFERENCES FOR SAFE NASOPHARYNGEAL SWAB

### Anatomy

Sufficient orientation or simple reminders of the anatomical background related to the procedure is expected to lower the possibility of adverse events demonstrated in the previous section. The important anatomical landmarks to remember are cribriform plate, anterior wall of the sphenoid sinus, anterior nasal spine, and nasal floor (Fig. 1A).<sup>45</sup> The angle of nasopharyngeal swab insertion into the nasal passage should be within 30°, a safe angle, from the nasal floor for safe testing (Fig. 1A). Upward swab insertion with angles greater



**Fig. 1.** Basic (A) anatomical and (B, C) procedural background information for a safe nasopharyngeal swab. (A) The blue horizontal line starts from the anterior nasal spine and ends on the external auditory canal. Nasopharyngeal swabs should be performed within 30° from the blue to redline. Clinicians should be cautious not to (B) hold the swab inappropriately and are recommended to (C) grip the swab appropriately. (B) The inappropriate way to hold the swab causes difficulty to enter the safety zone within 30° after passing the anterior nasal spine.

1: cribriform plate; 2: anterior wall of sphenoid sinus; 3: anterior nasal spine; 4: nasal floor.

Reproduced from the article of Mistry et al. (2021).<sup>45</sup>

than 30° not only results in inadequate sample collection but also can damage the skull base, including the cribriform plate and sphenoid, which can lead to CSF leakage.<sup>3,12,45</sup> Clinicians could predict the horizontal plane of the nasal floor and full depth of insertion by the line and length between the nostril and the external ear canal, respectively.<sup>45</sup> Clinicians need to hold the swab in an appropriate way for safe insertion just above the nasal floor, which requires delicate pressing in the lower direction (**Fig. 1B and C**).

### History taking and preparation for examination

Past or current medical history should be thoroughly investigated to avoid a preventable high-risk adverse event. The cautious medical history includes recent nasal trauma, surgery, significant septal deviation, chronic obstruction of the nasal passage, known skull base defects with or without encephalocele or meningocele, idiopathic intracranial hypertension, and severe coagulopathy.<sup>3,12,45,46</sup>

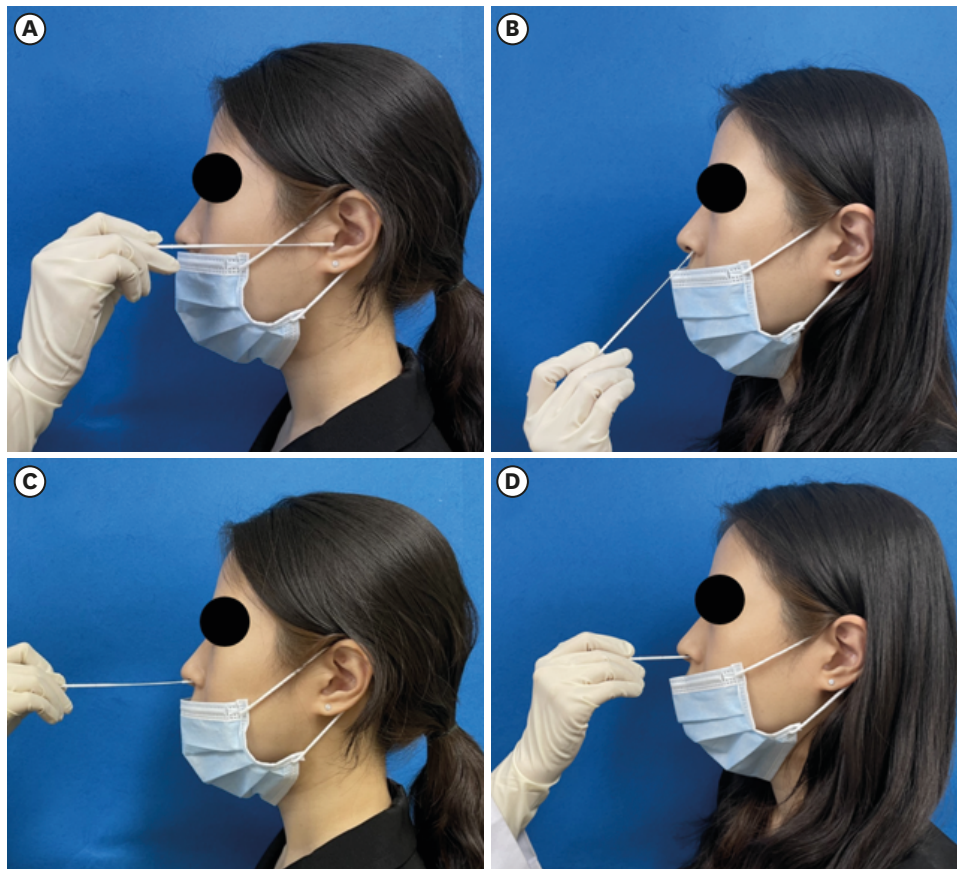
Strict adherence to the respiratory and contact precautions, recommended by the Centers for Disease Control and Prevention (CDC), during the wearing of personal protective equipment (PPE) including a gown, gloves, a qualified respirator, and a face shield is essential.<sup>46</sup> All personal items and jewelry should be removed before testing.<sup>47</sup> First, clinicians should wear a protective gown and wash their hands. The next steps are putting on non-sterile gloves and a respirator with a grading of N95 or higher. Finally, the equipment of a face shield is followed for face and eye protection.<sup>46,47</sup>

### Procedure

Clinicians are recommended to ask their patients to take off their face masks and blow their nose to clear possible secretions that hinder effective swab insertion.<sup>46</sup> Tilting the head slightly backward has been recommended in some studies for a more accessible nasal passage<sup>30,46</sup> but a safe and effective approach of nasopharyngeal swab does not seem to be significantly related to head extension.<sup>45</sup> Moreover, a head extension exposes the skull base to trauma if the clinician incorrectly performs the procedure.<sup>45</sup> Therefore, the recommended procedural steps start from requesting patients to gaze forward with the head positioned on a horizontal plane parallel to the floor.<sup>47</sup> Clinicians can predict the full depth of swab insertion by measuring the length between the nostril and the external ear canal (**Fig. 2A**). It is more ideal if the patient is comfortably seated with the back of their head against the headrest.<sup>47,48</sup> Second, the swab is appropriately held (**Fig. 1B and C**) and inserted into the nostril 2 to 3 cm parallel to the nasal bridge until it reaches the anterior nasal spine (**Fig. 2B**). Raise the hand that holds the swab approximately 70° upward at the same position and gently insert the swab along the nasal septum just above the nasal floor to the target area, nasopharynx, considering the anatomical structures of the nasal cavity and its surroundings (**Fig. 2C**).<sup>24,45-48</sup> The swab should be kept on the nasopharynx for several seconds and gently pulled back while rotating it within fingers (**Fig. 2D**).<sup>46-48</sup> Forceful movement should be attempted, especially in patients at a high risk of possible complications.<sup>24</sup>

### Handling of the specimen and undressing step

Samples collected on nasopharyngeal swabs were moved to collection tubes by breaking the swab at the groove. Sealed state and labeling should be checked, and surface disinfection should be performed.<sup>46,48</sup> Taking off PPE is recommended to be observed by other personnel, if possible, to lower the possible risk of contamination.<sup>46</sup> The first step is to remove the gown and gloves, followed by cleansing hands with decontaminating agents, including alcohol-based solutions. Second, new gloves are worn, and the face shield is removed. Third, we put



**Fig. 2.** The ideal procedural steps to obtain a nasopharyngeal swab specimen for coronavirus disease 2019 testing. **(A)** Before testing, the clinician can predict the full depth of insertion by measuring the length between the nostril and the external ear canal. **(B)** Insert the swab into the nostril no more than 3 cm parallel to the nasal bridge until reaching the anterior nasal spine. After passing the anterior nasal spine, **(C)** raise the hand that holds the swab about 70° upward and **(D)** delicately insert the swab along the nasal septum just above the nasal floor to the target area, nasopharynx. The swab should be stayed on the target area for several seconds and gently pull back the swab while rotating it within fingers, not making big circles with entire hands, to avoid excessive irritation (The pictures were demonstrated by the authors, Moon JW and Chae S with full agreement for publication).

on another pair of new gloves and remove the respirator. Finally, the gloves are removed, and hands are re-washed using decontaminating agents.<sup>46</sup>

## CONCLUSIONS

Our study reviewed the literature on possible complications and recommended procedural references for nasopharyngeal COVID-19 testing. Systemic education regarding high-risk factors and nasopharyngeal anatomical structures is expected to lower the incidence of adverse events. Nasopharyngeal swabs have been regarded as a safe and reliable screening tool for COVID-19<sup>3,48</sup>; however, it is essential to have sufficient anatomical and clinical knowledge for not only accurate examination to minimize the virus spread, but also to protect patients from preventable but often underestimated risks.

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