

Intranasal corticosteroids: patient administration angles and impact of education*

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Abstract

Introduction: Intranasal corticosteroids sprays (INCS) are first line treatment for allergic rhinitis and are frequently used for chronic rhinosinusitis. Improperly aiming INCS increases the risk of epistaxis and may decrease the efficacy of the medication. The goal of this study was to determine how patients position INCS for drug delivery and if verbal or written instructions improve their positioning.

Methods: Patients in rhinology clinics were photographed while administering a generic spray bottle. The angle of the spray bottle relative to the patients' head and a fixed background was determined.

Results: A total of 46 participants were included. The average spray angle for the right naris was 10.1° towards the septum and 67.2° below the Frankfurt Horizontal plane. The average spray angle for the left naris was 4.5° towards the septum and 62.2° below the Frankfurt horizontal plane. The angle of the spray bottle ranged from 50° toward the septum to 43° away from the septum. Only 8 patients aimed away from the septum for both nares. Patients who recalled receiving verbal and written instructions aimed the INCS bottle at the lateral wall and inferior turbinate in contrast to patients who only received one form of instruction or no instructions.

Conclusions: Most patients (83%) incorrectly aim INCS when compared to current guidelines. There was statistically significant improvement in the positioning of patients who reported receiving both verbal and written instruction; however, this study highlights a greater need for patient education.

Key words: intranasal corticosteroids, allergic rhinitis, chronic sinusitis, patient education

Introduction

Intranasal Corticosteroids Sprays (INCS) are widely used in the field of rhinology. They are commonly used treatments for a variety of conditions: allergic rhinitis, non-allergic rhinitis, acute rhinosinusitis, chronic rhinosinusitis without nasal polyps, chronic rhinosinusitis with nasal polyps and autoimmune disease with nasal manifestations ^(1,2). INCS significantly reduce cytokine production and inhibit inflammatory cell recruitment, reducing symptoms in inflammatory conditions ⁽¹⁻³⁾. INCS are effective in providing symptomatic improvement of nasal obstruction and rhinorrhoea and generally have an excellent safety profile ⁽³⁻⁵⁾.

INCS are first line treatment for allergic rhinitis (AR), a chronic disease which alone affects 10-20% of the global population ^(2,6,7). Given the prevalent use of INCS, it is important to understand how patients are using INCS to achieve optimal clinical outcomes and minimize patient morbidity.

Little evidence exists regarding the optimal method and positioning for INCS and manufacturer instructions are commonly difficult to understand ⁽⁸⁾. Patients are routinely encouraged to aim the nozzle so the bulk of the spray is deposited on the lateral wall of the nasal cavity and inferior turbinate ^(9,10). Aiming medially, at the septum, increases the risk of epistaxis

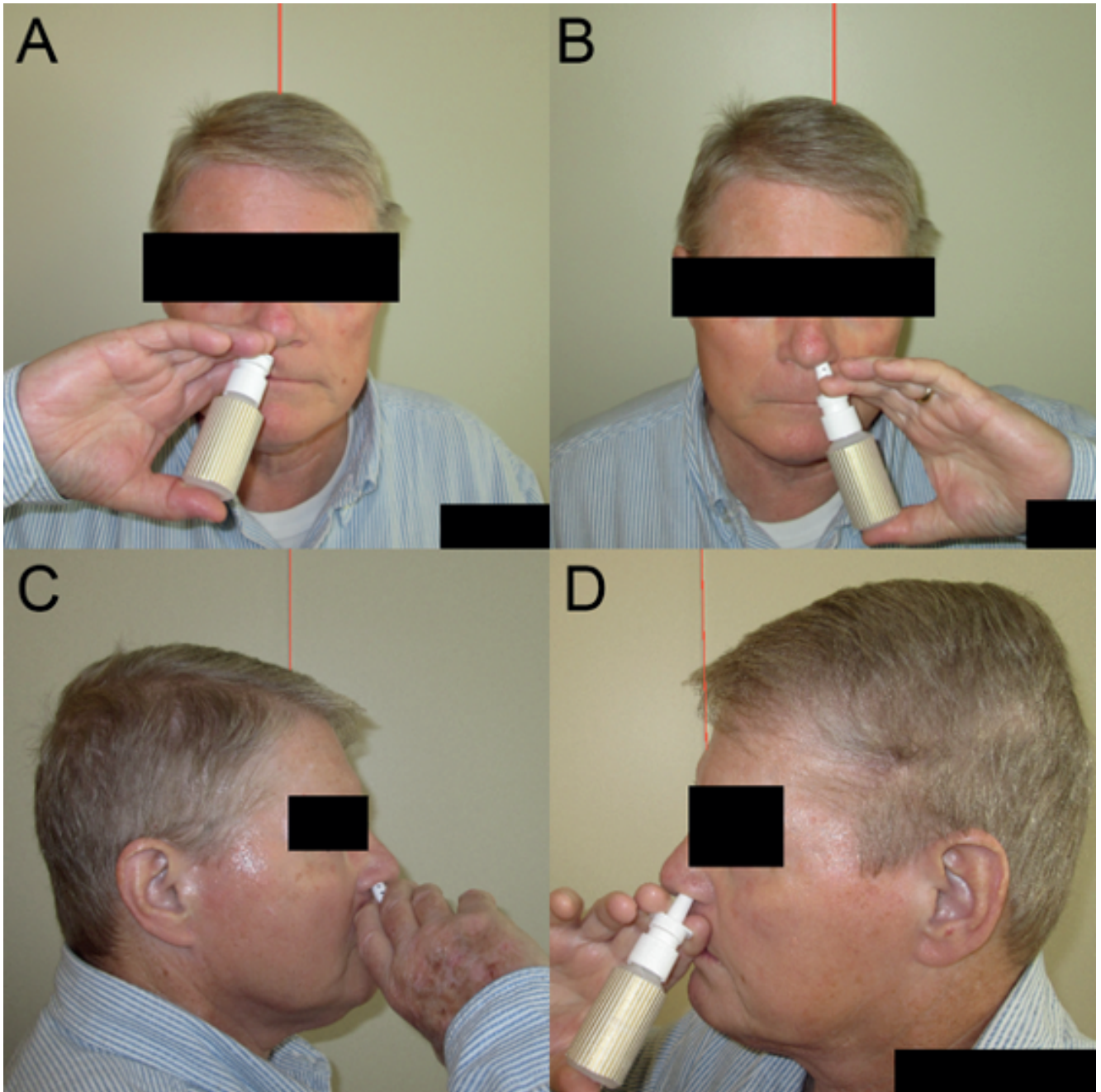


Figure 1. Photo documentation of a patient administering nasal spray into his right and left nares. Frontal picture of patient administering intranasal spray into the (A) right and (B) left nares. Profile picture of patient administering spray into his (C) right and (D) left nares.

and may decrease patient compliance^(7,11,12). To aim away from the septum, the European Position Paper on Rhinosinusitis and Nasal Polyps 2020 (EPOS 2020), encourages the use of the contralateral hand to the naris in which the INCS will be sprayed⁽¹³⁾. Using the ipsilateral hand has been demonstrated to increase the risk of epistaxis and decrease patient compliance⁽¹²⁾. Several studies have assessed the optimal method to achieve drug deposition on the inferior turbinate. Head orientation, spray bottle orientation, drug characteristics, device design, sinonasal anatomy and breathing rates all affect intranasal drug

transport^(12,14). Foo et al. found plume angle and administration angle significantly affect turbinate deposition while droplet size, viscosity, device and inspiratory flow rate had minimal effect on turbinate deposition⁽¹⁵⁾. Using nasal models, Shah et al. noted that tilt angle significantly affected deposition. They concluded that leaning the head forward to 23 degrees from the vertical while maintaining a vertical bottle achieved the maximum deposition on the inferior turbinate⁽⁹⁾. Further studies confirmed that head position, which in turn determines spray angles, is an important factor in nasal drug deposition^(14,16). Individual dif-

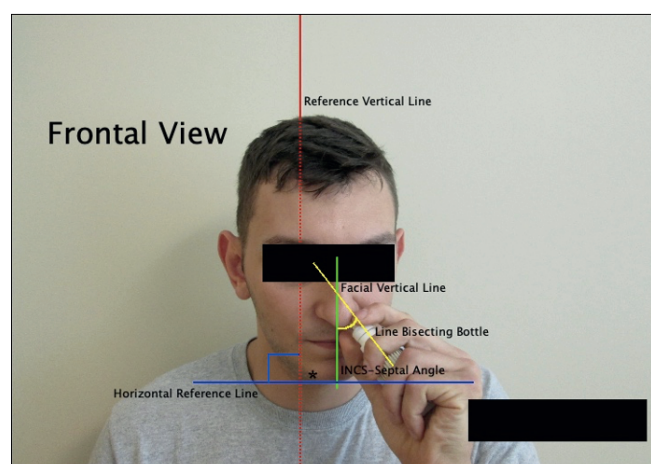


Figure 2. Photo documentation of the frontal view of a patient using spray bottle in the left naris. Frontal pictures were obtained on a wall with a vertical reference line (red). A facial vertical line (green) was then drawn from the nasion through the labrale superius (green line). A line bisecting bottle was drawn (yellow line). The INCS-Septal Angle was then calculated at the intersection of the facial vertical line and the line bisecting the bottle. The Head Frontal Tilt was calculated at the intersection of the reference vertical line and the facial vertical line, where the * is located. In this figure, the reference vertical and the facial vertical lines were parallel, so the Head Frontal Tilt was 0°.

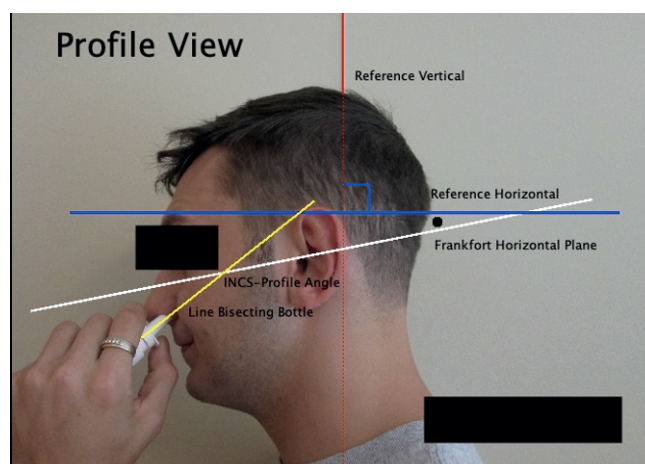


Figure 3. Photo documentation of the profile view of a patient using spray bottle in the left naris. Profile pictures were obtained on a wall with a vertical reference line (red). A line bisecting bottle was drawn (yellow line). Frankfort horizontal plane is drawn from the highest point of the opening of the external auditory canal through the lower margin of the orbit (white line). The INCS-Profile Angle was then calculated at the intersection of the line bisecting the bottle and the Frankfort horizontal plane. The Head Profile Tilt was calculated at the intersection of the reference horizontal line and the Frankfort horizontal plane, where the • is located.

ferences in anatomy have also been shown to be critical in INCS delivery^(10,14,16,17). Experimentally validated computational simulations of inhalation transport and drug delivery, carried out in anatomically realistic sinonasal reconstructions, have suggested that a personalized angle based off of a patient's intra-nasal anatomy might be a better solution to enhance topical delivery of sprayed particulates at the ostiomeatal complex and inside the sinus cavities^(10,18-20). While these studies did not specifically measure the effect of aiming towards/away from the septum, they demonstrate that spraying angles are critical in optimizing deposition of the medication.

Although the exact relationship between INCS deposition and clinical efficacy remains to be elucidated, most studies agree that deposition beyond the nasal valve is desirable for clinical outcomes⁽²¹⁾. Endoscopic sinus surgery is often performed to aid in delivery of INCS beyond the anterior nasal segments⁽²²⁾. The role of the nasal cycle in INCS deposition is unknown, although timing with regards to the nasal cycle may improve deposition and efficacy of INCS^(23,24). Given the prevalent use of INCS, and the desire to achieve optimal angles for drug deposition, it is important to understand how patients are self-administering these commonly used medications. When INCS are aimed medially, there is more observed epistaxis than when they are aimed laterally⁽⁷⁾. When patients experience epistaxis, they frequently stop using INCS, diminishing clinical outcomes⁽¹²⁾. The goal of this study was to determine how patients position INCS for drug

delivery and if verbal or written instructions improve positioning. We hypothesized that patients do not routinely use proper technique when administering INCS and that verbal and written instructions would improve positioning.

Materials and methods

This study was determined to be exempt by the University of North Carolina Institutional Review Board (IRB 19-0973) as an "benign behavioural intervention" only involving adults. Photo documentation of patients administering a generic intranasal spray bottle was obtained after a visit with a rhinologist at a tertiary care centre. Patients provided information on their age, sex, whether this was their first visit and whether they had recalled receiving verbal and/or written instructions on INCS positioning. Patients under the age of 18 were excluded from the study. Four pictures were taken of each patient: a frontal view of the patient spraying into the right naris, a frontal view of the patient spraying into the left naris, a right profile view of the patient spraying into the right naris and a left profile view of the patient spraying into the left naris (Figure 1). A vertical reference line was included in the background of the frontal and profile view (Figure 1, Figure 2, and Figure 3 redline) and a horizontal reference line was made by drawing a perpendicular line to the vertical reference line (Figure 2 and Figure 3; blue line). On the profile view, the Frankfort horizontal plane was drawn from the superior aspect of the external auditory canal through the infe-

Table 1. Definition of angles .

Angle	View	Line 1	Line 2
INCS-Septal	Frontal	Bisecting Bottle (yellow)	Facial vertical facial (green)
Head Frontal Tilt	Frontal	Reference Vertical (red)	Facial vertical (green)
INCS-Profile	Profile	Bisecting Bottle (yellow)	Frankfort Horizontal Plane (white)
Head Profile Tilt	Profile	Reference Horizontal (blue)	Frankfort Horizontal Plane (white)

Table 2. Position of patient's head relative to vertical reference line on the wall.

Angle	Right Naris (mean $\pm$ SD)	Left Naris (mean $\pm$ SD)
Head Frontal Tilt	6.1° $\pm$ 16.1 (away from reference vertical)	4.1° $\pm$ 5.8 (away from reference vertical)
Head Profile Tilt	0.1° $\pm$ 14.0 (below reference horizontal)	2.4° $\pm$ 15.9 (below reference horizontal)

rior orbital rim (Figure 3, white line) ⁽²⁵⁾. Two additional lines were drawn: 1) on the frontal view a vertical facial line was placed from the nasion through the labrale superius (Figure 2; green line) and 2) on the profile and frontal view a line bisecting the bottle was placed (Figure 2 and Figure 3; yellow line).

From these fundamental lines, angles were computed using ImageJ software (US Institutes of National Health, Bethesda, MD, USA) (Figure 2 and Figure 3, Table 1) ⁽²⁶⁾. The INCS-Septal angle was calculated as the angle between the facial vertical line and the line bisecting the bottle. The Head Frontal Tilt angle was calculated as the angle between the facial vertical line and the reference vertical line. The INCS-Profile angle was calculated as the angle between the Frankfort horizontal plane and the line bisecting the bottle. The Head Profile Tilt angle was calculated as the angle between the Frankfort Horizontal Plane and the reference horizontal line. Definitions of all computed angles are described in Table 1.

Results

A total of 46 patients at the rhinology clinics of a tertiary referral centre were included in the study. The mean age was 51 years with a range of 21 to 79 years. There were 24 males and 22 females. Four patients had never used INCS. Eleven patients reported previously receiving written instructions and 20 patients reported receiving verbal instructions. Eight patients reported receiving written and verbal instructions.

The INCS-Septal angle ranged from 50 degrees towards the septum (Figure 4, blue bottle) to 42 degrees towards the lateral

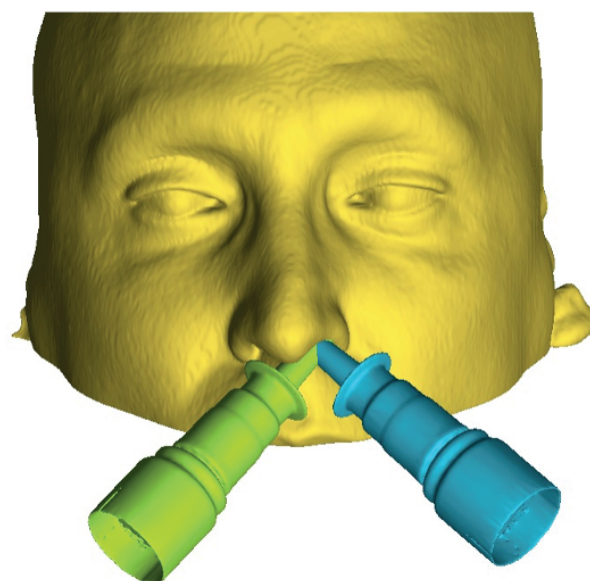


Figure 4. Range of Septal Angles. This figure demonstrates the wide range of angles at which patients sprayed INCS. The angles ranged from 50° to the septum to 42° degrees to the lateral wall.

wall (Figure 4, green bottle). For the right nostril the mean INCS-Septal angle was -10.5° (towards the septum) with a range of -39.3 to 23.1° (Figure 5; orange circles). On the left nostril the mean INCS-Septal angle was -4.5° (towards the septum) with a range of -50.3° to 42.4° (Figure 5; blue squares). 15 (32%) participants aimed toward the lateral nasal wall and inferior turbinate in at least one naris. Only 8 patients (17%) aimed away from the septum on both nares.

In patients who had not received prior instructions on the use of INCS, the mean INCS-Septal angle was -11.6° (toward the septum; 95% CI -16.2° to -7.1°). The average INCS-Septal angles with written or verbal instruction were -4.2° (toward the septum; 95% CI -24.8° to 16.42°) and -5.0° (toward the septum; 95% CI -11.4° to 1.4°), respectively. Patient who reported previously receiving both written and verbal instruction had an average INCS-Septal angle that was significantly more lateral than the group who reported no instructions with a mean angle of 3.3° (away from the septum; 95% CI -3.9° to 10.5°; $p = 0.006$; Figure 5B).

Patients were not instructed to utilize a dominant hand or switch hands during the simulated administration. When using the ipsilateral hand, the INCS-Septal angle was -12.7° (toward the septum; 95% CI -16.7° to -8.8°) while it was 1.8° (away from the septum; 95% CI -3.2° to 6.8°; Figure 5C) when using contralateral hand to naris. The difference was significant with $p < 0.0001$ (Figure 5C).

The INCS-Profile angles (Table 1) were determined relative to the Frankfort horizontal plane. An angle of 180° indicates the bottle was parallel to the Frankfort horizontal plane while an angle of

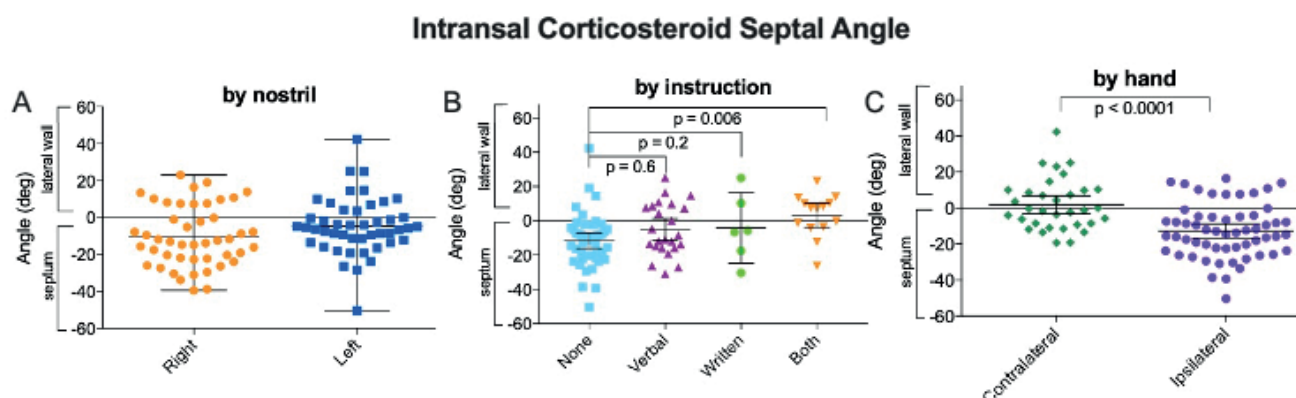


Figure 5. Intranasal corticosteroid septal angle by nostril, instruction level and by hand of application. (A) The mean INCS-Septal angle for the right naris (orange circles) was -10.5° (toward the septum) and the mean angle for the left was -4.5° (toward the septum). (B) Without instruction the mean INCS-Septal angle was -11.7° (toward the septum; blue squares). The mean angle with verbal instruction was -5.0° (toward the septum; up purple triangle) and was -4.2° written instruction (green circles). Patients who reported both written and verbal instruction had a mean INCS-Septal angle of 3.25° (away from the septum; down orange triangle; $p = 0.006$) (C) The average angle using the contralateral had was 1.8° (away from the septum; green triangles) compared to -12.7° using the ipsilateral hand (toward the septum; purple circles; $p < 0.0001$).

90 degrees indicates the bottle was perpendicular to the Frankfort horizontal plane (Figure 3). The INCS-Profile angle ranged from 85.4° to 149.9° degrees. The mean INCS-Profile angle for the right naris was 112.8° degrees and was 117.4° for the left naris. The position of the head relative to the vertical and horizontal reference line are found in Table 2.

Discussion

This study demonstrated enormous variability in the method by which patients administer their INCS. The majority (82 %) of patients aim their spray bottle towards their septum, even patients who reported previous instruction on how to properly utilize an INCS bottle. Of the 92 individual sides analysed, only 19 were aimed away from the septum (21%). Of the patients who recalled previous verbal instructions, only 17 of the total 40 sprays were aimed away from the septum (43%).

The wide range of angles used while administering INCS along with the low number of patients who spray away from the septum suggests that there is a greater need for patient education. In our practice, we routinely provide verbal and written instructions (see Additional information) to patients who are prescribed INCS, yet only 51% of all patients recall receiving any form of instruction. Even among patients who recall receiving instruction, only 43% aim away from their septum. This suggests that continual reminders may be necessary to help patients effectively use INCS.

While data on patients' dominant hand was not collected, using contralateral hand to naris lead to INCS-Septal angles that were more toward the lateral wall and inferior turbinate than when the ipsilateral hand was utilized. The angles of patients who used the contralateral hand improved INCS-Septal angles by

73%. Since using the opposite hand to the opposite naris leads to better INCS-Septal angles, providers should remind patients about this component of administering INCSs in particular. The combination of verbal and written instructions may seem redundant but had the greatest effect on patient positioning. Ensuring that patients receive instructions on spray technique and feedback while demonstrating how they position their bottle could be helpful in optimizing medication delivery. Given that patients are more likely to be non-compliant with medications when experiencing side effects, ensuring that patients are aiming away from the septum should improve clinical efficacy. This study assesses a static angle of INCS spray bottles in relation to the patient face and whether patients previously received instruction on correct usage. We did not account for inhalation while activating the device or dynamic movement of the device; however, the INCS-Septal angle was used to assess whether patients are attempting to follow current guidelines. Our group has previously demonstrated that there is not a single optimal spray angle for all patients, but that INCS deposition can be optimized based on each individual patient's anatomy which is not accounted for in this study. An interesting area of further research would be to consider giving patients INCS instructions based off individual anatomy. An additional limitation in this study was the use of a single generic spray bottle. Despite these limitations, we provide convincing evidence that patients do a poor job of aiming away from the septum and that education does provide some benefit. However, patient education needs to be optimized to improve INCS use.

Conclusions

In summary, there is wide variability in how patients self-admi-

nister INCS, with most patients not following current guidelines. Giving verbal and written instructions in which the provider emphasizes aiming away from the septum and using the opposite hand to opposite naris could improve patient understanding of how to properly administer INCS. Improving instruction methods could reduce patient morbidity and improve treatment efficacy of INCS.

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None.

Authorship contribution

ST collected data, processed data and wrote the manuscript. CE collected data and edited the manuscript. AZ provided feedback on experiment design. ZF wrote and edited the manuscript. SB assisted with experimental design, concept planning and manuscript editing. BT edited the manuscript. JK planned project design, figure design and data processing. BS provided the clinical question and reasoning and edited the manuscript. AK collected data, processed data and wrote the manuscript.

Conflict of interest

The authors have no conflicts of interest.

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Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

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Additional information

Instructions for spraying INCS given at our clinics:

Nasal steroid use instructions

Step 1. Prepare the nose. Blow the nose before administering the drug.

Step 2. Prime and activate the delivery device as recommended by the manufacturer.

Step 3. Position the head by tilting the head forward.

Step 4. Insert the tip of the applicator gently, avoiding contact with the septum.

Step 5. Aim the applicator tip about 45° from the floor of the nose and direct it at the outer corner of the eye on the same side to avoid traumatizing or spraying the septum.

Step 6. Close the other nostril gently with a finger.

Step 7. Sniff or inhale gently while delivering the drug.



Correct nasal spray direction.

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