# Convolutional Neuro network and fluid dynamic analysis for Obstructive sleep apnea (OSA) screening

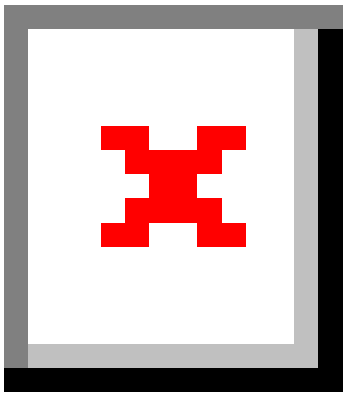
*2022 Research Aid Awards (RAA)*

***Dr Silvia Gianoni Capenakas***

capenaka@ualberta.ca
O: 587-594-9947

# FollowUp Form

## *Award Information*



*In an attempt to make things a little easier for the reviewer who will read this report, please consider these two questions before this is sent for review:*

- *Is this an example of your very best work, in that it provides sufficient explanation and justification, and is something otherwise worthy of publication? (We do publish the Final Report on our website, so this does need to be complete and polished.)*
- *Does this Final Report provide the level of detail, etc. that you would expect, if you were the reviewer?*

### Title of Project:*

Convolutional Neuro network and fluid dynamic analysis for Obstructive sleep apnea (OSA) screening

### Award Type

Research Aid Award (RAA)

## Period of AAOF Support
July 1, 2022 through June 30, 2022

## Institution
University of Alberta

## Names of principal advisor(s) / mentor(s), co-investigator(s) and consultant(s)
Dr. Manuel Lagravere Vich

## Amount of Funding
$5,000.00

## Abstract
(add specific directions for each type here)

Obstructive sleep apnea (OSA) impairment in children could lead to developmental, behavioral, and cognitive problems. OSA affects adults and children worldwide. A major concern in all patients with OSA is the pharyngeal collapse occurring in hypopnea (reduction in ventilation) or apnea (complete respiratory cessation). Orthodontic treatment has shown the potential to be a coadjuvant in the treatment of sleep-disordered breathing. Studies suggest a high correlation between sleep-disordered breathing and narrow maxilla and have shown a change in the dimension of the upper airway after orthodontic treatment.

The computational fluid dynamics analysis provides values for airway resistance. If resistance is elevated, one of two things could happen: the subject increases their effort of breathing to maintain the same airflow rates (e.g. determined by tidal volume and breathing frequency) or the subject maintains their effort and airflow rates decrease. Therefore, the accurate segmentation of the nasal cavity and analysis of the inspiratory flow is crucial to determine the real effect of the orthodontic treatment on the respiratory effort.

This research proposal aims (1) to develop a CFD approach to be used in geometries automatic segmented using deep learning; (2) to determine if an increase in the upper airway volume observed in the correction of transverse maxillary deficiencies can be related to decreased respiratory effort and an improvement in breathing capacity in adult patients that underwent maxillary expansion using mini screw rapid palatal expansion.

# *Respond to the following questions:*

## Detailed results and inferences:*
If the work has been published, please attach a pdf of manuscript below by clicking "Upload a file".
OR

Use the text box below to describe in detail the results of your study. The intent is to share the knowledge you have generated with the AAOF and orthodontic community specifically and other who may benefit from your study. Table, Figures, Statistical Analysis, and interpretation of results should also be attached by clicking "Upload a file".

For our 1st aim "to develop a CFD approach to be used in geometries automatic segmented using deep learning" we followed some steps:
1. Specific Aims
- Determine if Computational Fluid Dynamics (CFD) can be used to accurately estimate the pressure drop in a patient's airway from the nostril entrance to the oropharynx.
- Calculate theoretical values of Reynolds number and pressure drop to compare to the results from CFX. Determine the flow regime.
- Ensure that the segmented upper airway geometry obtained from a CBCT scan can be imported into CFX.
- Establish a robust procedure for preparing the upper airway geometry to be imported into CFX.
- Create a workflow that can be followed without extensive knowledge of CFD.
- Demonstrate the process in a single CFD case.

2. Studies and Results

A single upper airway geometry was used to establish a procedure that can be repeated, with the goal of using Computational Fluid Dynamics to determine the pressure drop through the upper airway. The geometry being used (Figure 1) was segmented from a CBCT scan using an algorithm trained by machine learning. This upper airway geometry was examined to determine which features are important to the flow and which features do not have an effect on the overall flow. It was determined that the sinuses are not important for our analysis because they are closed volumes that only have small openings into the turbinate region of the nose. This means that the sinuses have very little impact on the pressure drop.

Before CFD analysis begins, the range of average flow rates needs to be known to have an idea of the regime the flow will experience within this range. Research has shown that an average person breathes at a rate of about 60 liters per minute, although some cases can be as high as 150 L/min. The AI algorithm allows us to get the area of different cross-sections of the nasopharyngeal airway and has a tool to calculate the cross-section area at any slice and the total volume of the geometry. Taking these areas and flow rates the local Reynolds number can be estimated at various points through the airway to give us an idea of the flow regime. The Reynolds number varies throughout the nose, but stays between 600-3,000, which means that the flow will mostly be laminar with some slight turbulence at the highest inhalation rates.

The next step was to modify the geometry file of the nasal airway to prepare it to be imported into CFX. Reducing the volume of the sinuses reduces the computational time without significant change to the results, so we have established a repeatable method to cut off most of the volume of the sinuses. The modified geometry is shown in Figure 2. After the geometry has been modified, it needs to be meshed. To mesh the volume, we import it into CFX as an STL file, which is quite a tedious process and often results in errors in the geometry. The next step in the project is to find a more robust method to import the geometry into CFX.

A robust procedure was defined in CFX:

Procedure in CFX

1.

a. Fluid Models > Heat Transfer >Thermal Energy

b. Boundary details: Inlet

i. Option: Mass and flow rate = 0.001293

ii. Turbulence: Medium (intensity 5%)

iii. Heat transfer: Static temperature 25°C

c. Boundary details: Outlet

i. Option: Opening Pres. and Dirn

ii. Relative Pressure 0 P

iii. Turbulence: Medium (intensity 5%)

iv. Opening temperature 36°C

2. Solver Control

a. Advection Scheme: Specified Blend Factor: 1

b. Convergence Control: Max Iterations: 1100
c. Convergence Criteria: Residual target: 1e-6

Seven geometries were tested to evaluate the air resistance according to the pressure drop in T1 and T2. We still need to evaluate the rest of the geometries to then compare the results. Statistical analysis will be done to evaluate if there were any differences in the air resistance before and after orthodontic treatment.

## Were the original, specific aims of the proposal realized?*

Aim 1 was done, aim 2 was partially done and we are still working on it.

## Were the results published?*

No

## Have the results of this proposal been presented?*

No

## To what extent have you used, or how do you intend to use, AAOF funding to further your career?*

The AAOF funding was used in full and was crucial to allow this project to go further. Thank you AAOF!

Comment: *We appreciate your efforts and interest in advancing our specialty. We hope that you may still be able to complete your studies and look forward to the published results in the future.*

## Accounting: Were there any leftover funds?

$5,000.00

Comment: *This appears to be almost the total of the grant. Did you mean to indicate that $5000.00 is remaining? If so that must be returned to the AAOF.*

# *Not Published*

## Are there plans to publish? If not, why not?*

Yes, as soon as we have all data and results we'll write a manuscript for publication.

# *Not Presented*

## Are there plans to present? If not, why not?*

We aim to present the results at AAO 2024

# *Internal Review*

## Reviewer comments

## Reviewer Status*

Approved

# File Attachment Summary

## *Applicant File Uploads*

*No files were uploaded*