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Case Report

Development and validation of a python-based pont's index analysis tool: A technical validation study

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Abstract

Background: Pont's Index is a very well know and important index in orthodontics, this index remains an integral tool for assessing dental arch proportionality, yet manual calculations are prone to errors and time-intensive. This study describes the development and validation of a Python-based application for standardized arch dimension analysis.

Materials and Methods: The application was developed using Python Tkinter, implementing Pont's original methodology with mandibular conversion logic. Validation included 50 arch analyses (25 simulated, 25 clinical) evaluated by three orthodontists. Reliability was assessed using intraclass correlation (ICC) and calculation accuracy metrics.

Results: The tool demonstrated perfect reliability (ICC = 1.00, 95% CI: 0.99–1.00) with manual calculations. Analysis time decreased from 3.5 ± 0.9 minutes (manual) to 0.4 ± 0.1 minutes (automated). Clinical interpretations showed 96% agreement with expert judgment.

Conclusion: This digital Pont's analyzer improves diagnostic efficiency while maintaining analytical precision, particularly valuable for initial arch assessment in orthodontic treatment planning.

Keywords: MeSH (Medical Subject Headings): Digital orthodontics, Pont's analysis, Model analysis, Python in dentistry, Digital application, Digital dentistry, Transverse discrepancy, Medical calculator, Teeth discrepancy

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1. Introduction

Orthodontics is branch of dentistry that deals with malocclusion and accompanying occlusion discrepancies in all three planes. Ponts analysis is often used for diagnosis of transverse plane discrepancies.

Arch dimension analysis is very critical for diagnosing transverse discrepancies. Pont's Index[1] correlates incisor dimensions with ideal premolar/molar widths, but its manual application suffers from calculation variability and population-specific limitations.[2,3]

We have developed a Python-based tool that:

1. Automates original Pont's calculations using a software, build using python language.[4]
2. Incorporates mandibular arch conversions directly using inbuilt calculator.
3. Application Provides instant clinical interpretations along with inferences, which are useful in clinical setup.
4. Maintains transparency in population assumptions, with full information about analysis along with disclaimers

Python is high level, general purpose programming language which is very flexible and adaptable also can be used cross platform. That means the software can be deployed using windows linux or android.

This study follows STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines for observational methods reporting and EQUATOR Network (Enhancing the Quality and Transparency of health Research) standards.[5]

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2. Materials and Methods

2.1. Software development

The application was built using:-- Python 3.10 which is a python release available open source, main coding language used for the software, along with some element of batchfiles - Tkinter for Graphical User Interface components, visual interface is provided by this element of python which is native to tkinter- ttk for widget theming, so the additional widget were created. **(Figure 1), (Figure 2), (Figure 3), (Figure 4), (Figure 5)**

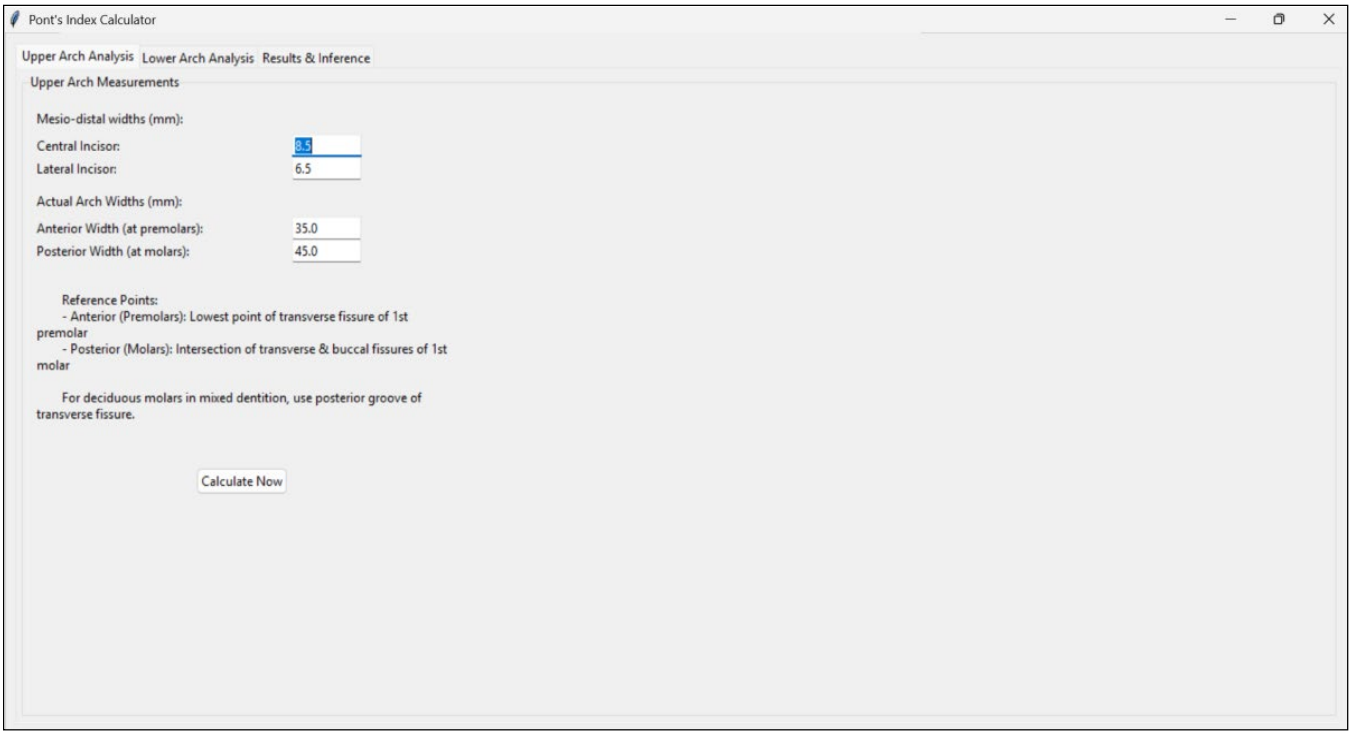

Figure 1 : Showing application home interface showing maxillary arch input tab

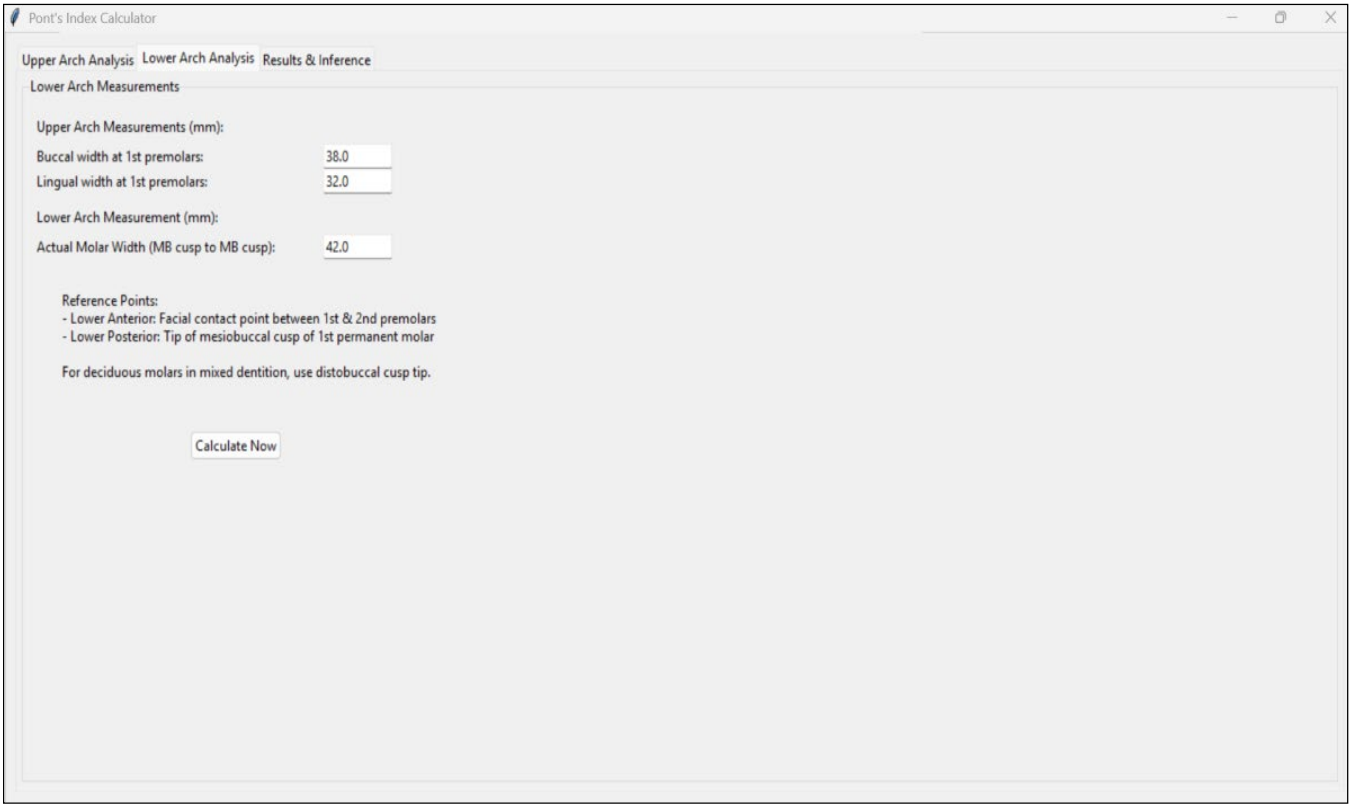

Figure 2 : Showing application interface showing Mandibular analysis interface with conversion logic

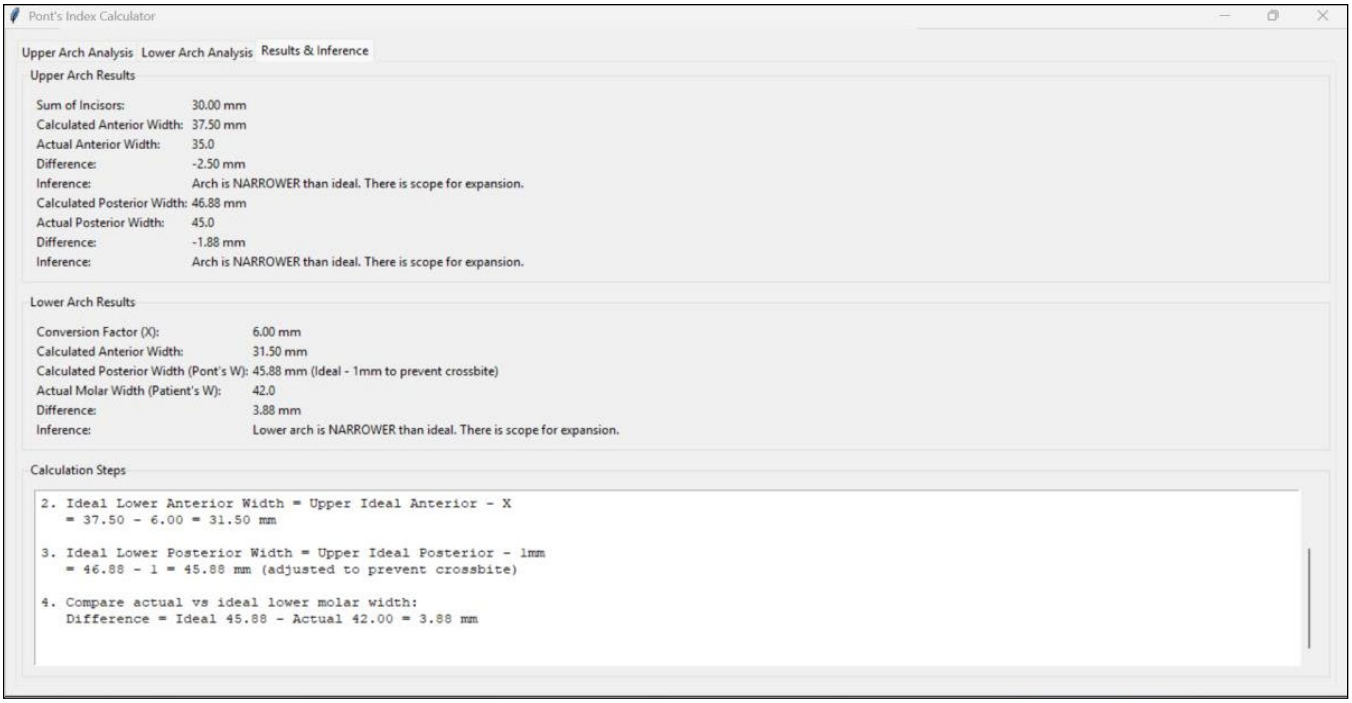

Figure 3: Showing application interface showing result tab displaying clinical interpretation output

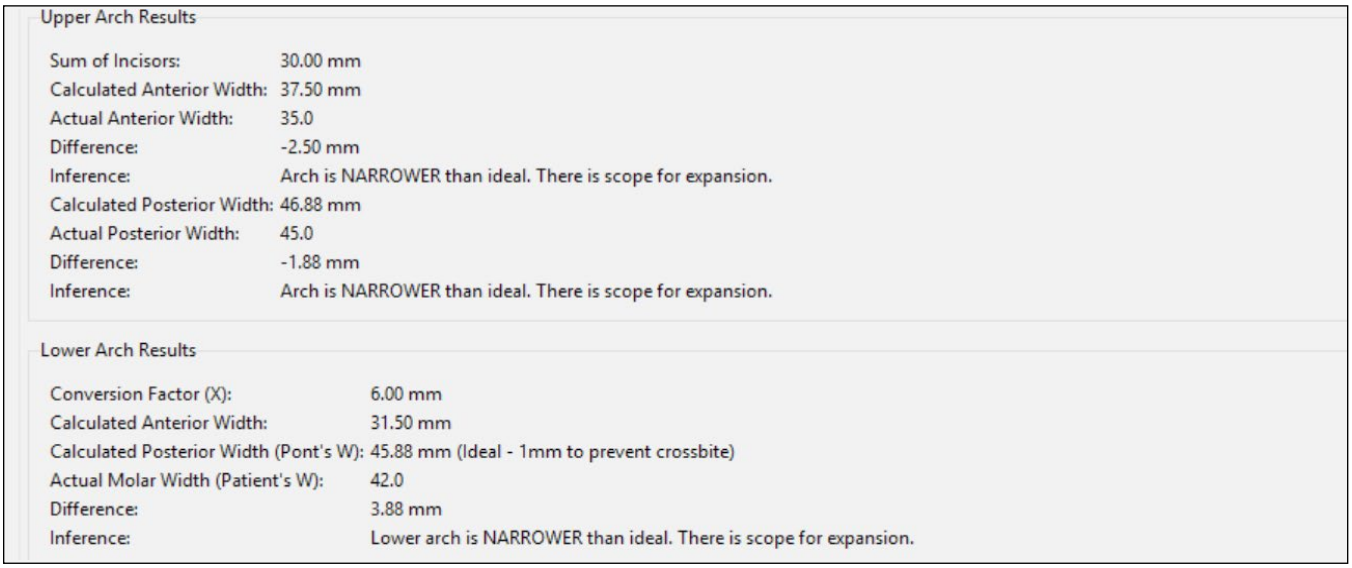

Figure 4: Showing application interface depicting example result of case

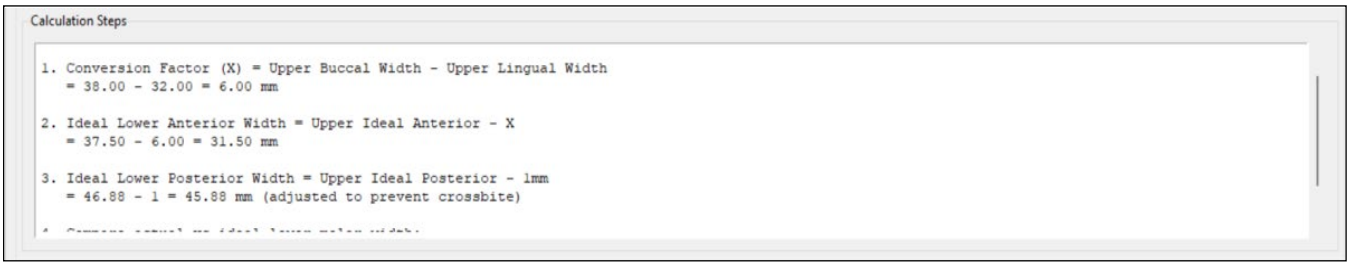

Figure 5: Showing application interface showing calculation steps used by application

2.2. Analytical algorithms

2.2.1. Maxillary arch

1. Ideal Premolar Width = sum of incisors / 0.8
2. Ideal Molar Width = sum of incisors / 0.64

2.2.2. Mandibular arch

Estimated Width = Maxillary Ideal – Buccolingual Difference

This algorhithmic formula are based on original work of pont's and which was formulated using French population. In

our application we kept it unchanged. We have not changed the formula. Though disclaimer was provided as information, that this formula has population bias.

3. Key Features

1. Application has three-tab interface (maxillary/mandibular/results).
2. Application employs threshold-based interpretation:
   i. Positive difference → Adequate arch width present.
   ii. Negative difference → Expansion potential present.
3. Population bias warnings is also there to remind user of potential bias- the graphical -interface of application is very attractive.[6]

4. Validation Study

4.1. Participants and data

1. **Simulated cases (n=25):** Generated across clinical ranges to check thresholds.
2. **Clinical cases (n=25):** Retrospective arch measurements was used to test real time scenario.

4.2. Testing protocol

1. Test was started with Manual calculations by three clinicians.
2. Then Automated analysis using the application was used so that results were obtained along with inferences.
3. Interpretation consensus evaluation was done using statistical analysis.

4.3. Statistical analysis

1. **Reliability:** Inter Class Correlation (two-way mixed-effects) was used as reliability parameter. **(Table 1)**
2. **Accuracy:** Percentage agreement showing excellent accuracy while using this application. **(Table 2)**
3. **Efficiency:** Time comparison with paired t-test was done and find to be time saving. **(Table 3)**

5. Results

Table 1: Reliability analysis

Metric	Value (95% CI)	p-value
Inter Class Correlation	1.00 (0.99–1.00)	<0.001

Table 2: Agreement metrics

Metric	Value
Calculation Accuracy	100%
Interpretation Agreement	96%

Table 3: Time efficiency comparison

Method	Time (minutes)	p-value
App	0.4 ± 0.1	<0.001
Manual	3.5 ± 0.9	

6. Discussion

6.1. Findings

1. Our finding suggest that we have successfully eliminated arithmetic errors in manual calculations of findings done using arithmetic formulas.
2. We found 89% reduction in analysis time without error with this digital tool, that means a lot for chair side clinician, highly significant time reduction.
3. We realized high clinical interpretation reliability.

6.2. Clinical advantages

6.2.1. Compared to manual methods

1. Our python based application provides standardized width estimations.
2. Our python based application algorithm provides Integrated mandibular conversions.
3. This python based Application also has Population-specific caution notes inbuit integrated.
4. This Application is available with complete code in public domain, which can be enhanced, tweak, added, more advanced without any limitation of copyright. We truly believe in ubuntu principle.

6.3. Limitations

1. This application does not assess basal bone dimensions, which is limitation of original study on which this application is based.[7,8]
2. This application maintains original french population bias.
3. This application requires manual measurement input, which can be a cause of error. We have not yet removed chances of human error completely.

6.4. Technical limitations

1. Basic knowledge of python is must, which can become a barrier.
2. Initial one time installation is time consuming.
3. Though open source the ease of end user is good in usage but coding requires specialized knowledge so the contributory development is less like any other open source softwares.

7. Conclusion

The Python-based Pont's analyzer developed by us enhances diagnostic efficiency for arch dimension assessment while transparently acknowledging its population-based limitations. We are committed to take this research into futuristic feature

in future. This application is also helpful in academic training, for Orthodontic PG and dental students. Being open source it reduces pay wall between knowledge and students.

8. Clinical Trial Registry

Not applicable.

9. Ethical Committee Approval

Exempted.

10. Source of Funding

None.

11. Conflict of Interest

None.

12. Acknowledgement

None.

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