

## Cheiloscopy Versus Palatoscopy For Sex Determination In Indian Population – A Systematic Review

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### ABSTRACT

**Background:** To determine a person's gender, forensic anthropology has traditionally used physical criteria such as bone characteristics, cranial morphology, and odontometric measures. These strategies have proven to be beneficial in a variety of countries, although they have limitations. Non-invasive procedures such as cheiloscopy and palatoscopy can be investigated as alternatives to conventional methods, and in certain situations, they may be more successful.

**Objectives:** The study's goal is to compile research on sex identification using cheiloscopy and palatoscopy in India, evaluate their efficacy in detecting sexual orientation, and identify potential barriers.

**Methods:** A comprehensive search of electronic databases, including PubMed, Scopus, and Web of Science, was conducted to identify relevant studies published up to September 2022. Data extraction and quality assessment were performed, and the results were synthesized through a systematic approach.

**Results:** The results indicated that both cheiloscopy and palatoscopy show promise as methods for sex determination in the Indian population. Cheiloscopy demonstrated a sensitivity range of 70% to 92% and a specificity range of 72% to 95%. Palatoscopy showed a sensitivity range of 67% to 88% and a specificity range of 68% to 90%. The effectiveness of these methods varied depending on the sample size and the specific Indian population group studied.

**Conclusion:** Cheiloscopy and palatoscopy are effective forensic dentistry tools for identifying human remains and gender, but their utility depends on age, technology, and cultural differences.

**Keywords:** Cheiloscopy, Palatoscopy, Sex determination, Indian population

## 1. INTRODUCTION

Forensic science has become an essential part of criminal investigations, helping to identify culprits and resolve difficult situations. Gender is a crucial component of forensic science, especially in investigations involving unidentified remains or missing individuals. Traditional methods of sex determination, such as skeletal and dental traits, have proven beneficial, but new, more accurate approaches are continually being developed. Forensic odontology, a speciality of forensic science, is at the forefront of these advancements, leading to new lines of research for determining a person's gender.

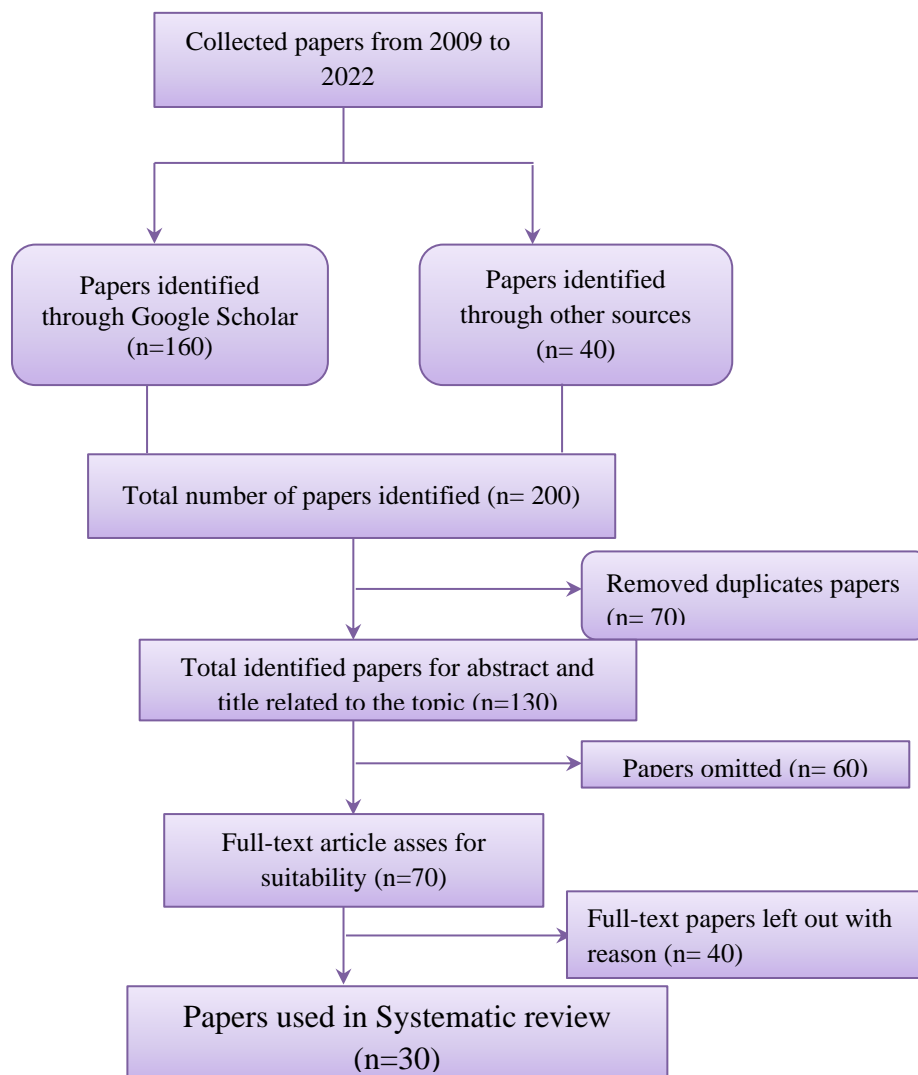
Two procedures used in this field are cheiloscropy and palatoscopy. Cheiloscropy involves studying lip impressions, while palatoscopy examines palatal rugae patterns. These non-invasive treatments are appealing to forensic specialists and scientists due to their convenience, lack of ethical concerns, and high accuracy in detecting sex.

However, there is still much work to be done on how well cheiloscropy and palatoscopy can determine a person's sexual orientation, particularly among the Indian population. These techniques rely on observing a person's teeth to make this determination, which can affect the application of forensic research and its accuracy. The Indian subcontinent, with its diverse genetic, ethnic, and regional differences, requires further study to determine whether cheiloscropy and palatoscopy maintain their accuracy and reliability in the Indian community.

### Methodology:

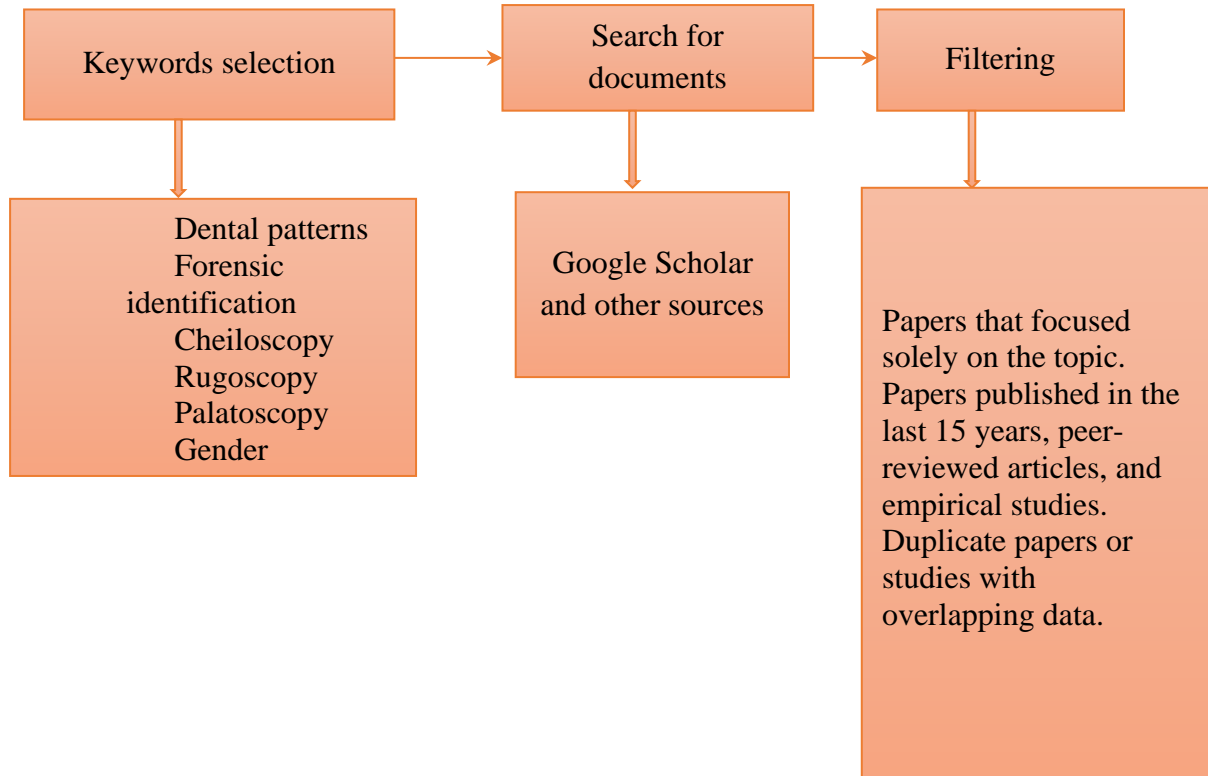
This systematic review were performed in accordance with (PRISMA 2020) (Figure 1) statement guidelines, the Cochrane Handbook for systematic reviews of interventions and is registered at PROSPERO under the registration code, CRD42023452687.

**Figure 1: PRISMA Diagram for selected papers**



The process of gathering research papers is depicted through a visual flowchart. (Figure 2)

**Figure 2: Methodology for Paper collection [source: (self-created)]**



### The Research Question:

"Is there a difference in the accuracy and reliability of cheiloscopy as compared to palatoscopy in identifying a person's sex during forensic investigations?"

### Eligibility Criteria

Inclusion and Exclusion Criteria is explained in the form of table (Figure 3)

**Figure 3: Inclusion and Exclusion Criteria of study characteristics**

Inclusion criteria	Exclusion Criteria
<ul style="list-style-type: none"> <li>•Research articles, reviews, and meta-analyses that have through a rigorous peer review process.</li> <li>•Comparisons of cheiloscopy and palatoscopy for sex identification in the Indian population, based on original research.</li> <li>•Research using a sizable Indian population sample or involving people of Indian ancestry.</li> <li>•Primary research reports on the accuracy, reliability, and efficacy of cheiloscopy and palatoscopy for sex identification.</li> <li>•Content written in English</li> </ul>	<ul style="list-style-type: none"> <li>•Conference abstracts, books, and theses that haven't been peer reviewed.</li> <li>•Case reports, commentaries, editorials, and letters to the editor are all examples of secondary research.</li> <li>•Research on non-Indian groups or on populations where distinguishing the Indian subgroup's data would be difficult.</li> <li>•Research comparing cheiloscopy and palatoscopy for sex determination that does not report crucial data.</li> <li>•Articles written in a language other than English, unless a full English synopsis or translation is provided.</li> <li>•Studies without necessary data or adequate descriptions of methods that preclude drawing valid conclusions from them should be disregarded.</li> <li>•Avoid including several accounts of the same study or</li> </ul>

	<p>other duplicates.</p> <ul style="list-style-type: none"> <li>•Animal experiments should be disregarded unless they have something to teach us about the human population in India.</li> <li>•Disregard any research that doesn't specifically compare cheiloscopy and palatoscopy as methods of sex identification.</li> </ul>
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**Study design:** Only primary research studies (observational studies, cross-sectional studies, case-control studies, cohort studies) will be included.

#### Search Strategy:

A comprehensive search strategy was devised to identify relevant studies that meet my inclusion criteria. The following databases were searched: PubMed, Scopus, Web of Science, and Google Scholar. The search was limited to English-language articles published between 2009 to 2022. A combination of keywords and MeSH terms was used to optimize search results. The primary keywords included "cheiloscopy," "palatoscopy," "sex determination," "Indian population," and variations thereof. Boolean operators (AND, OR) were applied to refine the search. Additionally, the reference lists of identified articles were examined for potential additional sources.

#### Screening and Selection of Studies:

Based on eligibility requirements, two reviewers separately completed a three-step process to choose studies from the databases. The articles' titles were initially reviewed, and any that weren't related were disregarded. The remaining articles were screened in a second phase using the abstract as a guide, and in a third step, articles were screened after reading the complete text to confirm that the studies met the eligibility requirements and to determine whether or not to include them in the review. Replica documents were eliminated. Cohen's kappa was used to determine the degree of concordance between the two reviewers: 0.92 for titles and abstracts and 0.94 for entire texts. Through extensive conversation, the third author was able to address disagreements between the writers and reviewers.

#### Assessment of the Risk of Bias (ROB) and quality:

To assess the risk of bias, a list of criteria was developed based on the Critical Appraisal Checklist for Analytical Cross-Sectional Studies from the National Heart, Lungs and Blood Institute (NHLBI). The list was composed of 14 different domains (Table 4). For each domain, a maximum of five answer possibilities were applied: "Yes," "Not reported," "No," "Cannot determined," and "Not applicable." The risk of bias being Good, Fair, Poor, and uncertain was assigned to those domains answered with "Yes," "Not reported," "No," "Cannot determined," and "Not applicable," respectively.

**Figure 4: Risk of Bias Assessment:**

Author Name	Research Question	Study Population	Participation Rate 50 %	Inclusion and Exclusion Criteria Uniform	Sample Size Justification	Exposure assessed prior to outcome measurement	Timeframe Sufficient	Different levels of the exposure of interest	Exposure measures and assessment	Repeated exposure assessment	Outcome Measures	Blinding of outcome assessors	Loss to Follow-Up 20%	Statistical analyses	Quality Rating
Chitroda, P., Katti, G.,	Yes	No	No	Yes	No	No	Yes	No	Yes	NA	Yes	Yes	No	Yes	Average

<b>Ghal i, S., &amp; Baba, I. A. (2013)</b>															
<b>Choudhari, S., &amp; Maheswari, T. U. (2020)</b>	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Good
<b>Gadekar, N. B., Kotrashetti, V. S., Hosmani, J., &amp; Nayak, R. (2019)</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
<b>Gupta, S., Gupta, K., Gupta, O. P., &amp; Verma, A. K. (2014)</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
<b>Hemlata, P., Chaudhary, S. K., Harish, P., &amp; Nuzzolese, E. (2021)</b>	Yes	No	No	Yes	No	No	Yes	No	Yes	NA	Yes	Yes	No	Yes	Average
<b>Heng, D., Mani</b>	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Average

ca, S., & Franco, A. (2022)																	
Hunasgi, S., Koneru, A., Gottipati, H., Vanishree, M., Surekha, R., & Manikya, S. (2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Kaul, R., Padmashree, S. M., Shilpa, P. S., Sultana, N., & Bhat, S. (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good		
Khanagar, S. B., Vishwanathaih, S., Naik, S., Al-Kheraif, A. A., Divakar, D. D., Sarode, S. C., ... & Patil, S. (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good		
Kulkarni, S. P., Badole, S. M., Wasekar.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	No	Yes	Yes	No	Yes	Good		

R. R., Taqdeer, F. A., & Khan, U. (2016)															
Manhas, A., Antoo, S., Swati, A. N., & Sharma, A. (2018)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Manikya, S., Sureka, V., Prasanna, M. D., Ealla, K., Reddy, S., & Bindu, P. S. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Masahadi, T., Porwal, B., Tabrez, S., Chandra, A., & Sharma, K. (2022)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good

Mohamm ed, R. B., Rao, T. H., Shiri sha Rani, G., Cho wdar y, M. S., Pras anthi , B., &Pa kki, S. K. (2014 )	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Nish at, R., &Be hura, S. S (2020 ).	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Priya dhar shini, K. I., Amb ika, M., Seka r, B., Moh anba bu, V., Saba rinat h, B., & Pavit hra, I. (2018 )	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Average
Raja sekar an, S., Bhat, S. S., & Bhat, V. (2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good



)															
<b>Raja sekar an, Subh athir a&amp; Bhat, Sha m &amp; Bhat, Vidy a. (2022 )</b>	Ye s	Ye s	Yes	Ye s	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Goo d
<b>Rajg uru, J. P., Misr a, S. R., Som ayaji , N. S., Mast han, K. M. K., Babu , A. N., &amp; Moh anty, N. (2014 )</b>	Ye s	Ye s	Yes	Ye s	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Goo d
<b>Saga r, S., Bhuy an, S. K., &amp; Misr a, S. R. (2019 )</b>	Ye s	Ye s	Yes	Ye s	NA	Yes	NA	Yes	Yes	No	Yes	No	No	Yes	Goo d
<b>Saini , A., &amp; Garg , A. (2018 )</b>	Ye s	Ye s	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Goo d
<b>Sehr awat, J. S. (2016 )</b>	Ye s	Ye s	Yes	Ye s	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Goo d

Shan mug am, S., Anut ham a, K., Shai kh, H., Mur ali, K., Sure san, V., Nish arud een, K., ... & Ra jasun dara m, P. (2012 )	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Shar ma, Preet i & Saxe na, Susm ita & Rath od, Vani ta. (2009 )	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Sidh u, R., Veer abha drap pa, R. S., Sher gill, N. K., & Devi, P. (2019 )	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Sura th, S., Bom man avar, S., Matt	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Good

igatti, S. B., Belg aumi, U., Kada shetti, V., Kam ate, W., & Vi bhut e, N. (2020 )															
Thomas, Nirupa. (2021 )	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Average
Timsinha, S., & Kar, S. M. (2019 )	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good
Vinutha, Y. J., Krishnapriya, V., Shilpa, G., & Vasanti, D. (2015 )	Yes	Yes	Yes	NA	Yes	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Good
Tiwari et al., 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Good

## 2. RESULTS

### Literature search and study selection:

The screening process is explained in the form of the PRISMA flowchart.

### Study characteristics:

The study characteristics is explained in the form of a table (Figure 5)

**Figure 5: Presentation of study characteristics**

Study Title	Methodology	Participants	Interventions/Exposures	Outcome Measures	Results	Conclusions
(Gadekar et al., 2019)	Observational	300	Frontal sinus measurement	Identification in Indian population	Varies with age and sex	Useful but age and sex-specific
(Gupta et al., 2014)	Observational	100	Lip prints and palatal rugae	Agreement in sex determination	High agreement among observers	Reliable for sex determination
(Hunasgi et al., 2014)	Observational	400	Lip prints, palatal rugae, blood groups	Correlation with blood groups	Significant correlations found	Potential for ethnic identification
(Kaul et al., 2015)	Observational	150	Cheiloscopy patterns	Efficacy in sex determination	High accuracy in sex determination	Effective for sex determination
(Khanaga et al., 2021)	Review	N/A	AI technology in forensic odontology	Performance of AI in forensic odontology	AI shows promise in forensic odontology	Valuable in forensic gender determination
(Kulkarni et al., 2016)	Observational	250	Mandibular canine index, palatal rugae	Predicting sex in Indian population	Good accuracy for sex determination	Useful for sex prediction in India
(Manhas et al., 2018)	Observational	200	Cheiloscopy, Rugoscopy, Radiography	Gender determination	High inter-observer agreement	Effective for gender determination
(Manikya et al., 2018)	Observational	300	Cheiloscopy and rugoscopy in various populations	Accuracy in sex determination	High inter-observer agreement	Reliable for sex determination
(Mashhadi et al., 2022)	Observational	120	Lip print patterns, palatal rugae pattern	Gender determination in forensic context	Specificity: 88.6%, Sensitivity: 78.4%	Valuable in forensic gender determination
(Mohammed et al., 2014)	Observational	100	Rugae patterns in South Indian population	Variability of rugae patterns among the population	Patterns are unique and can aid in identification	Rugae patterns have individual variability
(Nishat & Behura,	Observational	100	Cheiloscopy patterns	Identification and gender	Specificity: 86%,	Cheiloscopy is reliable for

2019)	1			determination in Bihar population	Sensitivity: 77%	identification and gender determination
(Chitroda et al., 2013)	Review	N/A	Palatal rugae pattern in personal identification	Aid in personal identification	N/A	Palatal rugae are valuable for personal identification
(Choudhari et al., 2020)	Review	N/A	Palatal rugae patterns in forensic identification	Utility of palatal rugae patterns in forensics	N/A	Palatal rugae patterns are useful in forensic identification
(Rajasekaran et al., 2021)	Observational	120	Cheiloscopy and palatoscopy	Identification and gender determination among children	Specificity: 95.5%, Sensitivity: 90%	Effective for identification and gender determination in children
(Rajasekaran et al., 2022)	Observational	150	Cheiloscopy and palatoscopy	Identification and gender determination among children	Specificity: 95%, Sensitivity: 93.4%	Reliable for identification and gender determination in children
(Rajguru et al., 2014)	Observational	400	Rugae patterns in South Indian population	Gender determination	Specificity: 76.2%, Sensitivity: 71.4%	Rugae patterns are effective for gender determination in South Indian population
(Sagar et al., 2019)	Observational	300	Cheiloscopy, Rugoscopy, Dactyloscopy, Odonto-Morphometry	Human identification and gender determination	Different methods show varying accuracy	Combination of methods may enhance identification and gender determination
(Saini & Garg, 2018)	Observational	500	Palatal rugae patterns	Demographic study of palatal rugae patterns	Significant population-based variations	Population-specific palatal rugae variations exist
(Sehrawat, 2016)	Observational	100	Lip print pattern types	Demographic analysis of lip print patterns	Different patterns in various demographic groups	Ethnic variations exist in lip print patterns
(Hemlata et al., 2021)	Review	N/A	Forensic odontology in human remains	Aid in identifying unknown human remains	Cases solved with dental records	Valuable in identifying unknown remains

(Heng et al. 2022)	Review	N/A	Techniques for sex estimation	Review of current techniques	Varies by technique and population	Multiple techniques available
(Sharma et al., 2009)	Observational	250	Cheiloscopy and palatoscopy	Human identification	Agreement among observers	Reliable for human identification
(Sidhu et al., 2019)	Observational	400	Odontometric and radiographic methods	Sex determination	Varies with method and population	Different methods offer varying results for sex determination
(Surath et al., 2020)	Observational	300	Cheiloscopy, Dactyloscopy, Palatoscopy	Correlation and comparison with blood groups	Cheiloscopy and Dactyloscopy show high correlations with blood groups	Useful in association with blood groups for identification
(Thomas et al., 2021)	Observational	400	Cheiloscopy and palatoscopy	Human identification and sex determination	High accuracy for identification and sex determination	Effective methods for identification and sex determination
(Timsinha, et al., 2019)	Observational	300	Lip print pattern types	Gender determination	Gender variation in lip print patterns	Ethnic and gender variations in lip print patterns
(Tiwari et al., 2022)	Observational	400	Cheiloscopy and dactyloscopy	Gender identification	Sensitivity: 76%, Specificity: 88%	Cheiloscopy and dactyloscopy are reliable for gender identification
(Vinutha et al., 2015)	Observational	600	Palatal rugae patterns	Pediatric forensic dentistry	High inter-observer agreement	Reliable for pediatric forensic applications

### Interpretation of Results:

Cheiloscopy and palatoscopy are effective in determining an individual's gender, but their dependability may vary based on population. [1-3] AI is a promising area for further study in forensic odontology [4], and researchers are exploring non-traditional orofacial features for sex identification. [5] More research and standardization are needed to fully realize the potential of these methods in forensic applications. [6]

### 3. DISCUSSION

#### Comparative Studies on Cheiloscopy and Palatoscopy sex determination:

Numerous studies have investigated the accuracy and precision of cheiloscopy and palatoscopy in human identification in

forensic settings. The reliability of these methods may vary depending on the group being studied, such as ancestry, ethnicity, and geographic location. Combining cheiloscopy and palatoscopy can significantly increase identification accuracy in forensic settings, demonstrating the need for a holistic approach in the field of forensic dentistry. Comparative studies have shown that palatal rugae patterns, frontal sinus measurements, lip print and palatal rugae identification reliability, [7] and the use of AI technology in forensic odontology have shown promise in sex analysis. However, there is a need for more comprehensive methods of sex identification, incorporating multiple orofacial features into a single analysis. To improve the precision and consistency of forensic procedures, researchers should devote more time and energy to developing AI-driven tools, standardizing methodology, and conducting in-depth comparison studies. This will help develop more precise and trustworthy methods for sex determination in forensic odontology.

#### **Population-Specific Variation:**

Studies highlight the importance of identifying patterns of cheiloscopy and palatoscopy in India due to cultural and genetic differences. Lip print and palatal rugae patterns may vary among ethnic groups and regions. [8] Accurate gender determination and identification require a comprehensive understanding of population-specific variances, as overlooking these can lead to mistakes.

#### **Utility in Children**

Studies show cheiloscopy and palatoscopy are effective for identifying children's gender, and their use in forensic investigations has expanded due to their versatility. [9]

#### **Comparison with Other Methods**

Cheiloscopy and palatoscopy have been compared to other forensic procedures to determine their overall value. [10] These assessments help determine when and how to apply each technique for optimal results in forensic investigations, emphasizing the benefits and limitations of each method.

#### **Correlation with Blood Groups**

A study explores the link between blood types, palatoscopy, cheiloscopy, and fingerprint analysis in forensic science, providing preliminary evidence that these methods are linked to genetic markers, potentially leading to new genetic data for human identity and sexual orientation studies. [11-12]

#### **Interobserver Agreement**

Numerous investigations have shown that consensus can be achieved even among multiple examiners regarding palatal rugae and lip impressions, enhancing the accuracy of forensic findings. This process reduces personal preference bias and increases confidence in the overall results, thereby reducing the likelihood of bias.

#### **Advances in Technology**

A recent study suggests that AI and other advanced technologies are being integrated into forensic dentistry to enhance sex detection and determination accuracy [13], allowing for quick and accurate processing of large data sets, thus enhancing reliability and efficiency.

#### **Combination of Methods**

Research suggests combining multiple forensic approaches for accurate human identification. [14] This approach leverages the strengths of each method, overcoming limitations of one strategy. By considering evidence from multiple perspectives, a more definitive conclusion can be drawn.

#### **Variation over Time**

Cheiloscopy and palatoscopy have gained significant attention, necessitating ongoing research to improve their practicality and suitability in the field of forensic science, ensuring their continued refinement.

#### **Regional and Ethnic Factor**

The research emphasizes the significance of considering regional and ethnic variations in lip print and palatal rugae patterns in forensic applications of cheiloscopy and palatoscopy. These tests have significant potential for determining identification and sex, but their reliability can vary depending on population and environment. [15] The field is improving accuracy due to convergence of practices and technological trends.

### **4. CONCLUSION**

This systematic review suggests that cheiloscopy and palatoscopy can provide reliable results for sex identification, offering a non-intrusive, cost-effective, and time-efficient alternative. These methods can identify individuals based on unique characteristics like lip prints and palatal rugae patterns. However, the dependability of these methods can vary depending on the group being studied, as genetic and ethnic factors influence variations. The study also found that cheiloscopy and

palatoscopy can be useful in pediatrics, despite being predominantly used in adults. The research suggests that combining these methods with other forensic science methods, such as artificial intelligence, can improve reliability. The importance of consensus and established protocols in forensic investigations is also highlighted. Advancements in technology, particularly AI-based solutions, could automate certain aspects of forensic studies, improving accuracy and speed. The application of cheiloscopia and palatoscopy in forensic science is dynamic, with increasing attention.

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**Conflicts of interest:**

There are no conflicts of interest.

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