

## THE RELIABILITY OF CHEILOSCOPY AND PALATOSCOPY IN HUMAN IDENTIFICATION: A SYSTEMATIC REVIEW

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**Abstract: Background.** Human identification by dental and other allied orofacial structures beholds importance for various purposes like criminal, legal, and aviation disasters. Lip prints and Palatoscopy bring added evidence to a crime scene that can be valuable. Over the years many studies have been conducted to determine the reliability of these methods.

**Aim.** To systematically evaluate reliability of the published studies pertaining to palatoscopy and cheiloscopy.

**Material and methods.** A literature search was conducted using ProQuest One Academic, Scopus, PubMed and Science Direct websites using predefined keywords. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) method was used for screening the articles.

**Results.** A total of 160 articles were obtained from the online search. 17 out of 160 articles were selected after screening. All the 17 articles were classified as having strong evidence when evaluated using critical appraisal skills program (CASP) criteria.

**Conclusions.** The data showed that cheiloscopy and palatoscopy have the significant potential in human identification. Cheiloscopy is more reliable in gender determination when compared to palatal rugae. Further research needs to be conducted in different regions of the world on larger populations to validate the results of the research.

**Keywords:** cheiloscopy, palatoscopy, lip prints, rugoscopy, palatal rugae, forensic odontology, human identification.

### INTRODUCTION

Human identity verification and identification is of a cardinal importance, and an integral part of forensic medicine [1]. Forensic odontology is a specialized branch of science that correlates dental sciences into other applications such as law and identification [2]. Human identification is necessary for ethical, social, and most importantly, legal purposes. As a matter of fact, it is incontrovertibly challenging to establish the identity of others due to the individualism of the specified person in terms of traits, and physical characteristics [3]. Identity verification requires the comparison of postmortem data with that of antemortem records of an individual to verify whether both belong to the same person [4]. Forensic odontology relies on various parameters such as DNA comparisons, dental records, lip prints, and palatal rugae patterns [5]. While DNA and

fingerprint analysis are the most used methods for identification, DNA records are considered highly successful in human identification [6]. However, the procedure of testing DNA is expensive and hence, unapplicable in some cases of dental analysis records [6]. Cheiloscopy identifies an individual using “lip prints”, which include the grooves and elevations of the labial mucosa [7]. Palatoscopy uses an individual’s distinct palatal rugae pattern that are arranged in a transverse direction on either side of the median palatine raphe in the anterior third of the palate behind the incisive papillae for identification [8]. Though there are studies some published studies regarding the reliability of cheiloscopy and palatoscopy, there is scarcity of systematic reviews in this area of research. Therefore, we conducted a systematic review to assess the reliability of cheiloscopy and palatoscopy in the published studies.

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## METHODS

### Research objectives and question

This systematic review was performed with the standard regulations of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The research question for the systematic review was - Can cheiloscopy and palatoscopy be reliable indicators for adult human identification?

### Search Strategy

Extraction of the reviews was done through the electronic databases: ProQuest One Academia, PubMed,

Scopus, Science Direct. The search was done for the articles from the date of inception and till September 2020. Non- English articles, reviews, opinions, commentaries, case reports were excluded. Only full text original studies in English language were included. The search was done separately by six reviewers. Strategic keywords using “AND” and “OR” were used as follows: (“Cheiloscopy” AND “Palatoscopy” AND “Forensic Odontology”) and (“Cheiloscopy” OR “Palatoscopy” AND “Forensic Odontology”). An additional google search was done after the removal of the duplicates and the articles within the exclusion criteria (Table 1).

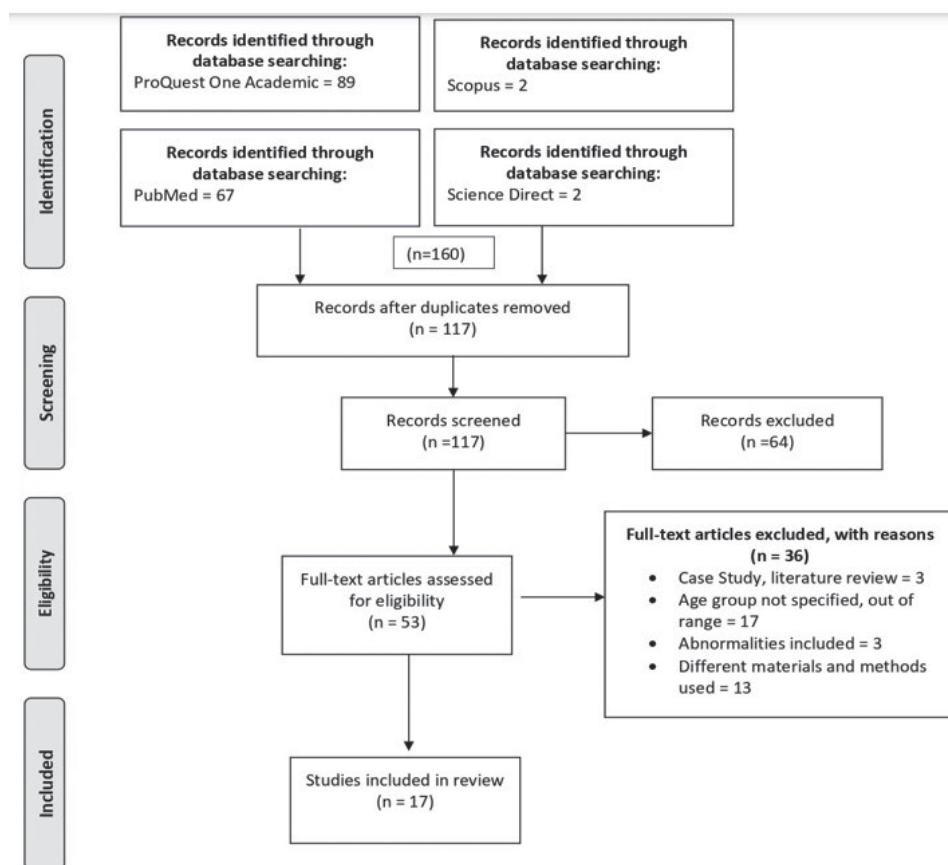


Figure 1. PRISMA flowchart of the review process.

Table 1. Search Strategies for each electronic database

Database	Search Strategies
ProQuest One Academic <a href="https://www.proquest.com">https://www.proquest.com</a>	“Cheiloscopy” AND “Palatoscopy” AND “Forensic Odontology” “Cheiloscopy” OR “Palatoscopy” AND “Forensic Odontology”
PubMed <a href="https://pubmed.ncbi.nlm.nih.gov">https://pubmed.ncbi.nlm.nih.gov</a>	“Cheiloscopy” AND “Palatoscopy” AND “Forensic Odontology” “Cheiloscopy” OR “Palatoscopy” AND “Forensic Odontology”
Scopus <a href="http://www.scopus.com/">http://www.scopus.com/</a>	“Cheiloscopy” AND “Palatoscopy” AND “Forensic Odontology” “Cheiloscopy” OR “Palatoscopy” AND “Forensic Odontology”
Science Direct <a href="https://www.sciencedirect.com">https://www.sciencedirect.com</a>	“Cheiloscopy” AND “Palatoscopy” AND “Forensic Odontology” “Cheiloscopy” OR “Palatoscopy” AND “Forensic Odontology”

### **Eligibility criteria**

The studies selected were limited to descriptive, cross-sectional, cohort and comparative studies. Other types of studies such as systematic reviews, abstracts, theses, commentaries, case reports, and opinions were excluded. Studies with non-human test subjects were not eligible for selection. Only studies published in the English language were included in the selection.

### **Data Extraction**

ProQuest One Academic, Scopus, PubMed and Science Direct are the search engines that have been used to find out all possible articles related to the research question, total number of 160 articles were recorded and identified through data base searching. Followed by screening all results to rule out any duplicated records, we ended up with excluding 43 articles. The remaining 117 articles were further screened by going through titles and abstracts, 64 studies were excluded from them. 53 articles were assessed for eligibility taking into consideration the predefined characteristics that were identified in the inclusion/exclusion criteria. Among the 53 articles 36 were excluded because of inappropriate age group, discrepancies between methodology and results. 17 articles were found eligible for this systematic review that could fulfill and match our research-based guidelines and protocols (Fig. 1).

### **Studies Quality Assessment**

Assessment of quality and validity of each included study was conducted using the Critical Appraisal Skills Programme (CASP) [9]. The checklist is based on the questions that were used to classify the strength of the study with subjective criticism according to scores of (Yes, No). Score range of (0-33%), (34%-66%), (67%-100%) is classified as weak, moderate, or strong evidence respectively.

## **RESULTS**

### **Study Characteristics**

Of the seventeen studies, fifteen were conducted in India (Sharma *et al.* 2009 [7], Raghu *et al.* 2013 [10], Manhas *et al.* 2018 [11], Nagalaxmi *et al.* 2015 [12], Gupta *et al.* 2014 [13], Manikya *et al.* 2018 [14], Divyadarshini and Kumar 2019 [15]; Ramakrishnan *et al.* 2015 [16]; Kunero *et al.* 2013 [17]; Kolli *et al.* 2013 [18]; Konidena *et al.* 2020 [19], Sekhon *et al.* 2014 [20]; Shanmugam *et al.* 2012 [21]; Choudhari *et al.* 2020 [22] and Guruprasad *et al.* 2014 [23]) one in Saudi Arabia (Domiati *et al.* 2010 [24]) and one in Sudan (Ahmed

and Hamid. 2015[8]). The studies varied in population from 60 till 966. Several study designs were used such as Cohort (1 study), cross sectional (13 studies) comparative (2 studies) and descriptive (1 study). Detailed characteristics of each eligible study was mentioned in detail in Table 2.

### **Study Outcome**

One of the studies demonstrated that Lip print patterns (LPP) and Palatal rugae patterns (PRP) are unique to each individual and have potential as a supplementary tool, along with the dentition, to establish the identity of an individual [14]. Some results showed that although lip prints give an indication about the gender of an individual, it cannot be used as conclusive evidence in dental profiling [11]. One of the articles showed that lip prints of branched type were most commonly seen in females and cross section in males [13]. Another article showed that lip morphology did not vary significantly between genders however, new patterns such as dots and complex patterns helped in gender determination [18]. For the rugae pattern, the curved pattern was more prevalent in the population in both males and females following this the wavy pattern was more prevalent in females and straight pattern in males [11]. Another article showed that there was no significant difference found in the total number of rugae in males and females and the wavy shape was more common in females while the curved shape was more commonly seen in males [8]. All the 17 articles were classified as having strong evidence when evaluated using critical appraisal skills program (CASP) criteria (Table 3). The technique used by the 17 eligible studies have been mentioned in Table 4.

## **DISCUSSION**

The traditional methods for personal identification include anthropometry, fingerprints, sex determination, age estimation, measurement of height, and differentiation by blood groups, DNA, and odontology [25]. Human identification by dental and other allied orofacial structures is important for various purposes like criminal, legal, mass casualties, aviation disasters, legal heirship, marital affairs, divorce, human trafficking, child abuse and crime detection [26]. Both cheiloscropy and rugoscropy are relatively simple techniques not requiring any complex instrumentation [16]. While cheiloscropy is useful to identify the living, palatoscopy has been successfully used in necro-identification. Both cheiloscropy and rugoscropy have

Table 2. Characteristics of the eligible studies

Author, Year	Condition	Study Design	Country	N	Main Findings	Method of Classification
(Mutalik <i>et al.</i> , 2013) India	Cheiloscopy & Palatoscopy	Cohort Study	India	100 (All Females)	Uniqueness of pattern in individual is higher proving cheiloscopy, palatoscopy & dactyloscopy but the correlation between the three identification methods showed no correlation between the three.	<u>Cheiloscopy</u> : Suzuki and Tsuchihashi <u>Rugoscopy</u> : Modified Lysell classification.
(Manhas <i>et al.</i> , 2018) India	Cheiloscopy & Palatoscopy	Cross-sectional Study	India	60 (30 Males, 30 Females)	Lip prints can indicate gender but aren't conclusive in dental profiling. Type I was more prevalent in females, while Type I' was for males. The curved rugae pattern was more prevalent in the population in both genders.	<u>Cheiloscopy</u> : Suzuki and Tsuchihashi classification -1970 <u>Palatoscopy</u> : Thomas and Kotze (1983) and Kapali <i>et al.</i>
(V <i>et al.</i> , 2015) India	Cheiloscopy & Palatoscopy	Cross-sectional Study	India	61 (30 Males, 30 Females)	The study shows the uniqueness of lip prints and canine odontometrics and they can aid in sex determination and can be considered as an ancillary forensic tool in identification	<u>Cheiloscopy</u> : Tsuchihashi <u>Palatoscopy</u> : Modified Lysell classification
(Sharma <i>et al.</i> , 2009) India	Cheiloscopy & Palatoscopy	Cross-sectional Study	India	100 (50 Males, 50 Females)	No lip prints matched and that lip print pattern was unique to every individual. No significant difference was found in the total number of rugae in males and females. The wavy shape was more common in females, curved shape was more commonly seen in males. No particular characteristic pattern of rugae was observed in either sex.	<u>Cheiloscopy</u> : Tsuchihashi — <u>Palatoscopy</u> : Lysell classification
(Gupta <i>et al.</i> , 2014) India	Cheiloscopy & Palatoscopy	Cross-sectional Study	India	378 (189 Males, 189 Females)	Lip print of branched type was most commonly seen in females and cross-section in males. Wavy pattern was most common in males and females in palatal rugae	<u>Cheiloscopy</u> : Suzuki and Tsuchihashi
(Manikya <i>et al.</i> , 2018) India	Cheiloscopy & Palatoscopy	Comparative Study	India	180 (60 each group)	This study clearly demonstrates that LPP and PRP are unique to each individual and have potential as a supplementary tool, along with the dentition, to establish the identity of an individual. Cheiloscopy and rugoscopy stand as potential techniques in identifying an individual compared to DNA fingerprinting.	<u>Cheiloscopy</u> : Vahanwala (2000) <i>et al</i> <u>Palatoscopy</u> : Kapali S <i>et al</i>

Author, Year	Condition	Study Design	Country	N	Main Findings	Method of Classification
(Divyadharsini & Kumar, 2019) India	Cheiloscopy	Cross-sectional Study	India	100 (50 Males, 50 Females)	It was observed that no lip prints matched and that lip pattern was unique to every individual, thus aid in personal identification, which was similar to observation of other studies. Therefore, it is a method of identification and high accuracy in gender estimation.	Suzuki and Tsuchihashi classification
(Ramakrishnan et al., 2015) India	Cheiloscopy	Cross-sectional Study	India	100 (50 Males, 50 Females)	Type III (2%), Type IV (1%), and Type V (1%) were found in the female population. It was concluded that cheiloscopy holds potential for use in sex determination. The current research on latent lip prints has shown a considerably new aspect of cheiloscopy, and the use of lysochrome dyes has proved its effectiveness as an agent to develop latent lip prints.	Vahanwala et al. (2000). Suzuki et al. (1970)
(Koneru et al., 2013) India	Cheiloscopy	Cross-sectional Study	India	60 (30 Males, 30 Females)	There is difference in the lip print pattern between the 2 populations although subtle. In males Type 4 and Type 5 patterns were predominant and Type 1 and Type 1' in females.	Suzuki and Tsuchihashi
(Padmavathi et al., 2013) India	Cheiloscopy	Cross-sectional Study	India	250	Upper lip played a role in gender determination in the present study, while lower lip did not. The lip patterns were distributed in segments and it was found that D and R patterns were commonly found in upper lip (U1 and U2) of males and CP pattern in upper lip (U1 and U2) of females. Lip morphology did not vary significantly between genders. However, new patterns such as dots and complex patterns helped in gender determination. This study proved the individuality of Saudi lip prints as no identically similar lip-print patterns appeared in two subjects. Even when two subjects exhibited the same type of groove in the same area of the lip, there was specificity in the site and pattern of groove branching or reticulation.	Suzuki and Tsuchihashi's classification
(El Domiaty et al., 2010) Saudi Arabia	Cheiloscopy	Descriptive Study	Saudi Arabia	966 (426 Males, 540 Females)		Modification of the Renaud's classification 1973

Author, Year	Condition	Study Design	Country	N	Main Findings	Method of Classification
(Kataria <i>et al.</i> , 2020) India	Cheiloscopy	Equivalence Trial	India	500 (250 Males, 250 Females)	Accuracy of lip prints for gender identification was higher when compared with finger prints. The combination method using both lip prints and finger prints was found to be the most accurate amongst the three methods so it can be used as a supplementary tool in sex determination. The findings of our study clearly indicated the individuality of palatal rugae pattern and their potential as evidence in forensic dentistry. The observations of our study seem to indicate that it may be possible to use the palatal rugae as an adjunct with other methods to determine the sex of an individual	<u>Cheiloscopy</u> ; Suzuki and Tsuchihashi
(Sekhon <i>et al.</i> , 2014) India	Palatoscopy	Cross-sectional Study	India	100 (50 Males, 50 Females)	The findings obtained showed that the use of palatal rugae to assign sex among Sudanese Arabs is not recommended.	Thomas and Kotz classification (1983).
(Ahmed & Hamid, 2015) Sudan	Palatoscopy	Cross-sectional Study	Sudan	100 (50 Males, 50 Females)	The discriminant function equation obtained from the different rugae shapes in the study was highly accurate enough to distinguish the Southern and Northern Indian population with the classification accuracy of 87.8%	Lysell, Thomas and Kotze
(Shanmugam <i>et al.</i> , 2012) India	Palatoscopy	Cross-sectional Study	India	940 (466 South Indians, 474 North Indians)	Each individual had a unique rugae pattern. Curve form (34%) of rugae was the most common in both genders whereas none of the casts exhibited the point form. Following the curve form, the sinuous form was common in males and line form in females.	Kapali <i>et al</i>
(Choudhari & Maheswari, 2020) India	Palatoscopy	Cross-sectional Study	India	100 (50 Males, 50 Females)	The palatal rugae were prominent, permanent, and unique for individuals and can be used as identification for forensic purposes. This is widely used in edentulous patients where dental identification is not possible and in patients where other body parts were burnt and decomposed.	Martin dos Santos (1983).
(Byatnal <i>et al.</i> , 2014) India	Palatoscopy	Comparative Study	India	500		Thomas <i>et al.</i> , and Kapali <i>et al.</i>

the potential to identify an individual. Lip prints are more reliable in identifying the sex of an individual as compared to palatal rugae patterns [16].

Lip prints and palatal rugae hold potential as a supplementary tool, along with the dentition, to establish the identity of an individual [14]. Personal identification can be usually done by comparing pre-mortem and post-mortem records. It is difficult to find antemortem records for lip prints in contrary to palatal rugae which can be found in form of dental casts, maxillary dentures, and intra-oral photographs. It can be used as necro-identification technique [27]. Brazilian Aeronautic Ministry demands palatal rugoscopy of all its pilots in order to ensure their identification in case of accidents [27]. This is because it was proven to withstand harsh conditions and diseases without deterioration and changes in its pattern since its very well protected and hence can survive post-mortem damage [28]. Palatal rugae patterns are usually classified on the basis of length, shape, direction, and unification [29]. Wavy, straight, curved and circular are common types [29]. Most common rugae pattern in males is the wavy pattern followed by curved one [29]. On the other hand, females showed wavy and curved patterns as the most predominant followed by the unification diverging pattern [29].

Lip prints are identified as early as sixth week of intrauterine life and rarely changes resisting many pathologies [30]. Palatal rugae patterns are formed toward the third month of intrauterine life and gain orientation pattern at birth and their final shape in adolescence and remaining stable throughout life [31].

All the eligible studies required samples that

were free from any pathologies and abnormalities. Most of the studies used similar materials and methods applying them. Regarding chelioscopy, most studies assessed the lip prints by obtaining an impression using cellophane tape on a white bond paper and visualizing it using a magnifying glass. However, Ramakrishnan *et al* used lysochrome reagent Sudan Black B to visualize the lip prints [6]. In palatoscopy, most of the studies was assessed using graphite lead pencil and visualized using a magnifying glass on the cast. However, studies like Manhas *et al.* used specific software packages to visualize and assess the lip prints and palatal rugae [11]. Ramakrishnan *et al.* showed that lysochrome reagent Sudan Black B was effective in the development of clear latent lip prints from a human corpse's skin [16]. Multiple methods have been used to come out with basic guidelines that could help in human identification, varying between traditional (cast impressions) and modern (software packages) methods. Both ways gave an accurate result, but software application allow the performance of the procedure with greater efficiency and precision [32]. Furthermore, one of the most important advancements provided by software packages is the elimination of the need to use impression materials thus providing more comfort to the patient [32]. However, Ahmed and Hamid showed that the traditional analysis was less complex, less expensive, and quicker [8]. The method of classification was an important factor that differed between the eligible studies, most of the chelioscopic studies followed the classification by Suzuki and Tsuchihashi, and most of the palatoscopic studies followed Thomas and Kotz classification and Lysell or Modified Lysell [33].

Many studies presented a small sample size, which could affect the reliability of the results. Secondly, in some studies, the dental impressions and casts were constructed manually, which increases the possibility of potential errors and deformities in case of palatal rugae patterns collection. Additionally, the manual application of lipstick/lysochrome may lead to possible human errors. Most studies were performed in India; therefore studies need to be done among other different populations. Further research work on larger samples and application of advanced statistical methods is required to validate its use in forensic application.

Although the results of these studies have shown variable significance, additional studies with adjustments to certain factors must be conducted to improve their reliability. First, larger sample sizes are required to validate the outcomes of studies. The studies

**Table 3.** Assessment of quality of study of the eligible studies using CASP (Critical Appraisal Skills)

Author, Year	Strength	%
(Mutalik <i>et al.</i> , 2013) India	Strong	80%
(Manhas <i>et al.</i> , 2018) India	Strong	80%
(V <i>et al.</i> , 2015) India	Strong	70%
(Sharma <i>et al.</i> , 2009) India	Strong	75%
(Gupta <i>et al.</i> , 2014) India	Strong	83%
(Manikya <i>et al.</i> , 2018) India	Strong	83%
(Divyadharsini & Kumar, 2019) India	Strong	70%
(Ramakrishnan <i>et al.</i> , 2015) India	Strong	77%
(Koneru <i>et al.</i> , 2013) India	Strong	70%
(Padmavathi <i>et al.</i> , 2013) India	Strong	75%
(El Domiaty <i>et al.</i> , 2010) Saudi Arabia	Strong	83%
(Kataria <i>et al.</i> , 2020) India	Strong	79%
(Sekhon <i>et al.</i> , 2014) India	Strong	73%
(Ahmed & Hamid, 2015) Sudan	Strong	73%
(Shanmugam <i>et al.</i> , 2012) India	Strong	82%
(Choudhari & Maheswari, 2020) India	Strong	77%
(Byatnal <i>et al.</i> , 2014) India	Strong	72%

had minimal geographical variation, as most of them were conducted in India. Further tests are required in different regions. The type of classification used for cheiloscopy and palatoscopy each had their own criteria, which played a role in differentiation of the lip prints and palatal rugae. In addition, the methods used to obtain the lip prints and palatal rugae differed from one another, each having their own potential errors. A

**Table 4.** Specified Method of Assessment for each eligible study

<b>Author, Year</b>	<b>Assessment</b>
(Mutalik <i>et al.</i> , 2013) India	Cheiloscopy: Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper. Palatoscopy: Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on cast) to highlight the rugae.
(Manhas <i>et al.</i> , 2018) India	Cheiloscopy: Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens. Palatoscopy: Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on photographs) to highlight the rugae.
(V <i>et al.</i> , 2015) India	Cheiloscopy: Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens. Palatoscopy: Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on cast) to highlight the rugae.
(Sharma <i>et al.</i> , 2009) India	Cheiloscopy: Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens. Palatoscopy: Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on cast) to highlight the rugae.
(Gupta <i>et al.</i> , 2014) India	Cheiloscopy: Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens. Palatoscopy: Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on cast) to highlight the rugae.
(Manikya <i>et al.</i> , 2018) India	Cheiloscopy: Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens. Palatoscopy: Alginate impression, cast done using dental stone, drafting pencil to highlight the patterns.
(Divyadharsini & Kumar, 2019) India	Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens.
(Ramakrishnan <i>et al.</i> , 2015) India	Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by lysochrome reagent Sudan Black B, digitized by using a digital scanner.
(Koneru <i>et al.</i> , 2013) India	Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and visualized by magnifying lens
(Padmavathi <i>et al.</i> , 2013) India	Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper, photographed and digitally enhanced.
(El Domiaty <i>et al.</i> , 2010) Saudi Arabia	Lipstick applied by lipstick applicator using single stroke, white bond paper and tissue papers to obtain impression on specified papers in three methods.
(Kataria <i>et al.</i> , 2020) India	Lipstick applied by lipstick applicator using single stroke, cellophane tape to obtain impression on white bond paper and digitized using a digital scanner
(Sekhon <i>et al.</i> , 2014) India	Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on cast) to highlight the rugae.
(Ahmed & Hamid, 2015) Sudan	Alginate impression, cast done using dental stone, drafting pencil, lighting, and magnifying glass (on cast) to highlight the rugae.
(Shanmugam <i>et al.</i> , 2012) India	Alginate impression, cast done using dental stone, drafting pencil to highlight the patterns.
(Choudhari & Maheswari, 2020) India	Alginate impression, cast done using dental stone, drafting pencil to highlight the patterns.
(Byatnal <i>et al.</i> , 2014) India	Alginate impression, cast done using dental stone, drafting pencil to highlight the patterns.



unified classification system and method of obtaining the data are needed to ensure cohesive results. Most of the studies found did not compare both cheiloscopy and palatoscopy, so more articles are necessary.

**In conclusion**, according to various studies, it has been proven that lip prints and palatal rugae patterns are unique to every individual. Thus, cheiloscopy and palatoscopy have the potential in human identification with lip prints being more reliable in identifying human

gender. Although most studies have shown significant statistical results, further research need to be conducted in different regions and on larger populations to validate the results of the research. In addition, a unified classification method and method of sampling will help remove any bias and offer a fixed criterion for comparison. The results of the study could allow for a future creation of a database for forensic identification.

**Table 5.** Main limitations of the eligible studies

Author, Year	Limitations
(Mutalik <i>et al.</i> , 2013) India	Authors presented a small sample size (n=100). Not enough information was presented about how the sample size was collected. Dental impressions and casts were made manually increasing the possibility of potential errors and deformities in case of palatal rugae patterns collection. Further studies are required as no new information was provided only confirmation of previous studies.
(Manhas <i>et al.</i> , 2018) India	Authors presented a sample size that is small (n=60). Other factors need to be taken into consideration, such as the difference in thickness of lips between males and females. Dental impressions and casts were performed manually (with the potential inherent errors and deformities)
(V <i>et al.</i> , 2015) India	Authors presented a sample size that is small (n=60).
(Sharma <i>et al.</i> , 2009) India	Authors presented a sample size that is small. Type of lipstick not considered for. Lip print vary in registration due to mobility and pressure applied. Dental impressions and casts were made manually which could lead to potential errors.
(Gupta <i>et al.</i> , 2014) India	Manual application of lipstick/lysochrome may lead to possible human errors.
(Manikya <i>et al.</i> , 2018) India	Manual application of lipstick & dental impressions and casts may lead to possible human errors.
(Divyadharsini & Kumar, 2019) India	Authors presented a sample size that is small (n=100). Not enough information was presented about how the sample size was collected.
(Ramakrishnan <i>et al.</i> , 2015) India	Authors presented a sample size that is small (n=100). Manual application of lipsticks/lysochrome may lead to possible human errors.
(Koneru <i>et al.</i> , 2013) India	Authors presented a sample size that is small (n=100). Study need to be done among different populations.
(Padmavathi <i>et al.</i> , 2013) India	Lip print vary in registration due to mobility and pressure applied; manual application of lipstick may lead to potential errors.
(El Domiaty <i>et al.</i> , 2010) Saudi Arabia	Manual application of lipstick/lysochrome may lead to possible human errors. Further studies concerning standardization of the pressure applied to the lip during recording the prints is recommended to allow fast and accurate assessment of lip-print patterns
(Kataria <i>et al.</i> , 2020) India	Lack of high quality of clinical evidence.
(Sekhon <i>et al.</i> , 2014) India	Authors presented a sample size that is small (n=100). Not enough information was presented about how the sample size was collected. Dental impressions and casts were made manually increasing the possibility of potential errors and deformities in case of palatal rugae patterns collection. Further studies are required as no new information was provided only confirmation of previous studies.
(Ahmed & Hamid, 2015) Sudan	Authors presented a sample size that is small (n=100). Study need to be done among different populations.
(Shanmugam <i>et al.</i> , 2012) India	Dental impressions and casts were made manually which can lead to potential errors
(Choudhari & Maheswari, 2020) India	Authors presented a sample size that is small. Further research work on larger samples and application of advanced statistical methods is required to validate its use in forensic application.
(Byatnal <i>et al.</i> , 2014) India	No high-quality evidence was provided thus further studies and explanations were required

### **Conflict of interest**

The authors declare that they have no conflict of interest.

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