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## A study on identification of knuckle print

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### Abstract

Knuckle Print Impressions is also called Knuckle crease impressions. This is a unique pattern formed by ridges and furrows of the skin on knuckles. These are the impressions can be left behind the surfaces when an individual knuckles come into contact with it. In forensic science, knuckle prints are very much similar to the fingerprints that is, they can be used for identification purposes. Recognition of Knuckle marks and proper photographic preservation are the major aid in the investigation. The Finger knuckle print plays a major role in recognizing the person. There is not commercial biometric recognition system based on finger knuckle print to identify the minutiae present in knuckle print that is very much different from traditional method. Our main aim of research to know the uniqueness in the prints by identifying the minutiae according to their age and occupation and know the identification the chances of correlation between knuckle prints to their age and their minutiae features.

**Keywords:** Finger-knuckle prints, individuality, minutiae characteristics, fingerprints, photography, investigation

### 1. Introduction

In Forensic Science, finger knuckle prints play very important role in individualising by its biological nature (Pankanti S, Bolle R. M *et al.* 2000) <sup>[1]</sup>. It is a biological characteristic feature by human hand together with a fingerprint and palm print refers to inherent patterns of skin (Vidhyapriya R, Lovelyn Rose S. *et al.* 2019) <sup>[2]</sup>. It is formed at the joints and in the finger back surfaces (Lilly Dan, Lucina Hackman *et al.* 2023) <sup>[3]</sup>. The fusion features of these knuckles achieve the complementary advantages and improve the recognition accuracy (Li, Wenwen *et al.* 2022) <sup>[4]</sup>. Mostly it is seen that in a normal human hand has four fingers each contains three bone segments and three joints in each finger but in case of thumb there are two bones and two joints. Joints are also called phalanges (Tim D. White, Pieter A. *et al.*; 2005) <sup>[5]</sup>.

In this research we observe many new things such as the image patterns of skin folds and creases. The outer surface of finger knuckle is highly unique and serves as distinctive biometric identifier as comparison on the inner surface of hand is widely used to hold the things or objects (Aoyama S, Ito K *et al.* 2014) <sup>[6]</sup>. They are relatively stable and remain unchanged during the life of a person (Usha K., Ezhilarasan M. *et al.* 2016) <sup>[7]</sup> Generally it is seen that the minutiae of finger knuckle prints are small and has specific details of a finger knuckle print is mostly used to identify the person from the crowd of people. (Hegde C, Phanindra J, *et al.* 2011) <sup>[8]</sup>.

### 2. Materials and Methods

#### 2.1 Materials

- 50 subjects, male and female, above 30 years of age and with different occupations.
- 48MP [f/1.7; FOV 79°; 6P; AF] Mobile camera lens without a flash light during the daytime with a black background.
- Adobe Light room app.

#### 2.2 Methods

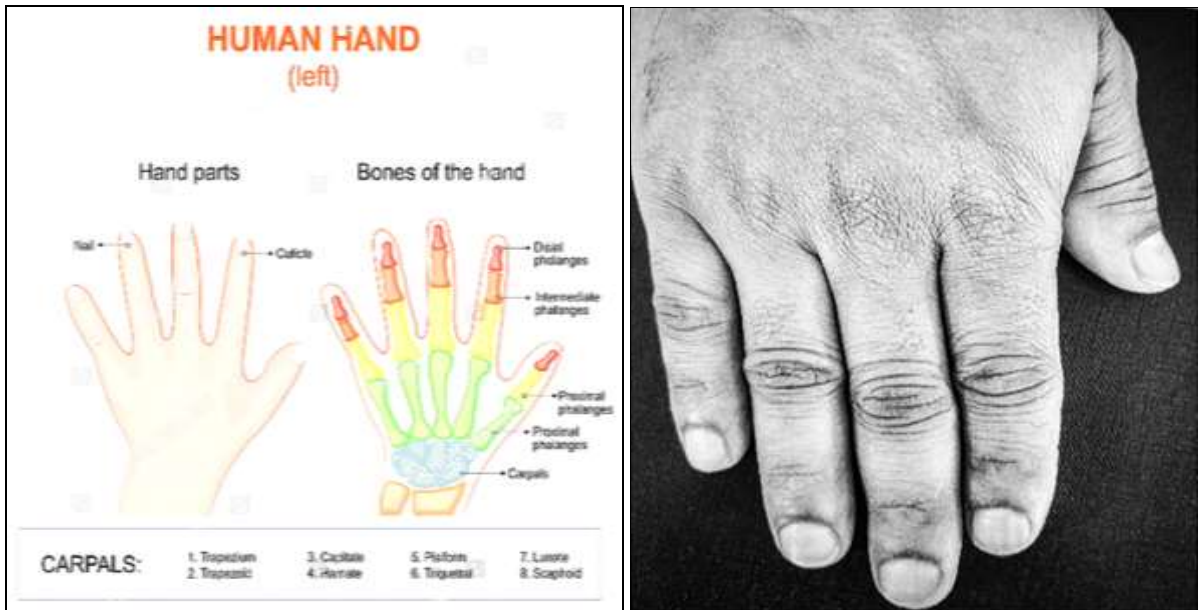
We took fifty subjects, both male and female, whose ages were above 30 years, with different occupations. The samples of knuckle prints for identification were captured. The images, to increase their sharpness and clarity, get converted into black and white images through B and W 07 profiles by using the Adobe light room app.

These samples were analyzed with the naked eye. These samples were studied for class characteristics and individual minutiae features. We observed many characters such as size, shape, orientation and alignment for each individual minutiae characteristic such as their ridges endings, bridge. Bifurcations, enclosures etc. We also observed their minutiae like trident, trifurcations, opposite trifurcations, opposite bifurcations, angle brackets, infinity, branched,

kaph and joint bifurcation.

**3. Results and Discussions**

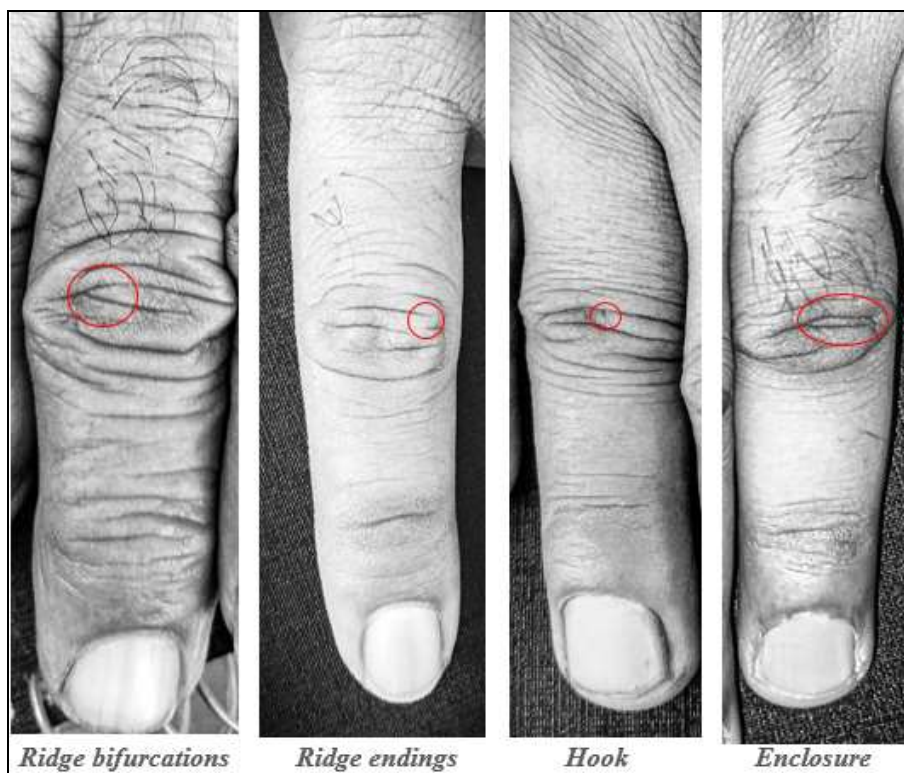
Finger Knuckle print is a biological characteristic and has a unique texture feature of human hand together with a finger print and palm print that is inherent patterns of skin in the phalanges region and back surface of fingers.

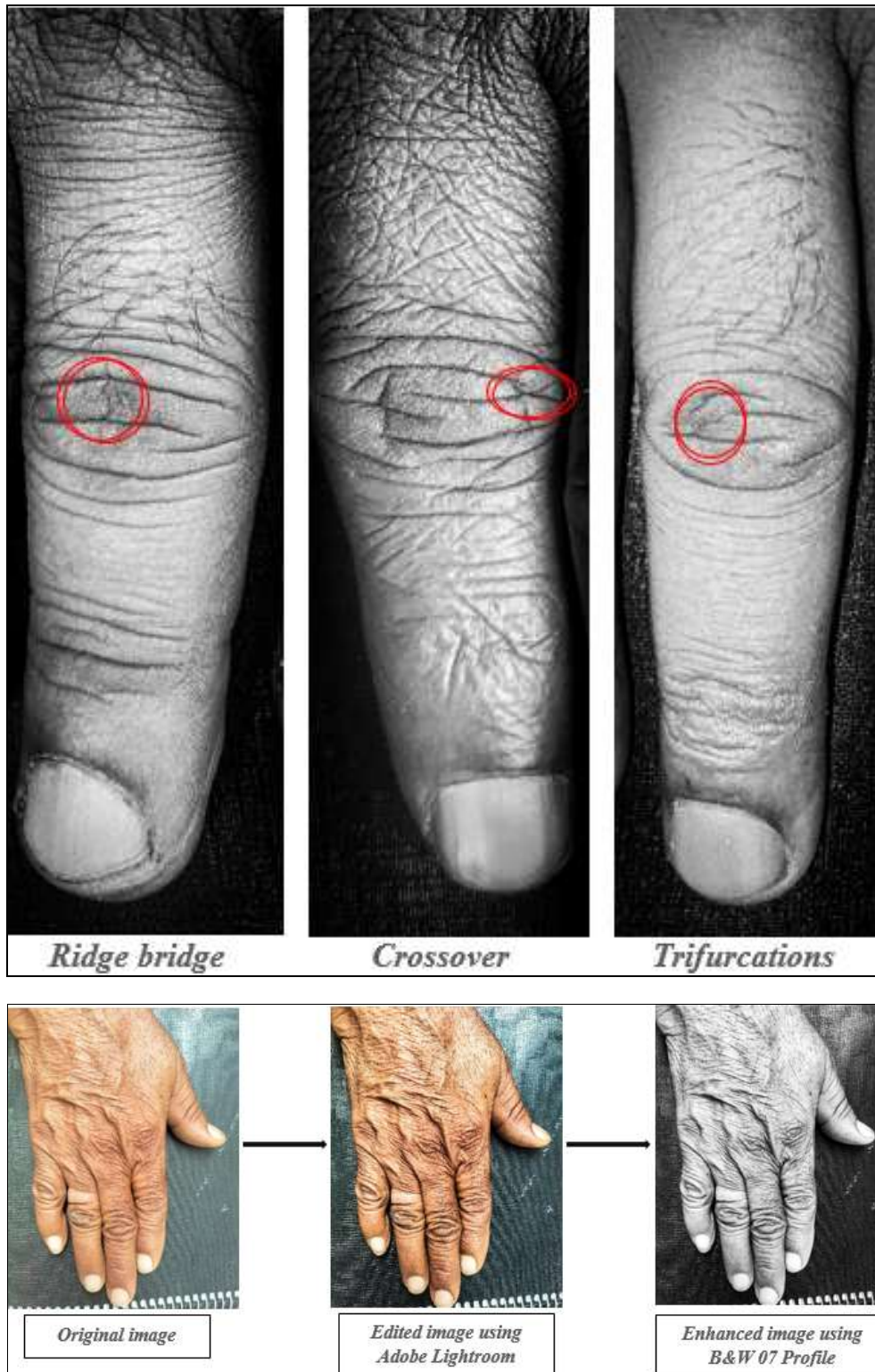


**Fig 1:** Human left hand

There are the regions of the skin folds and creases. The finger knuckle prints have many minutiae including the ridge endings and bifurcations. Ridge endings are the finger knuckle ridge ends and bifurcations are the ridges split into two branches. It includes:

Ridge dots are small, round protrusions and appear on fingerprint ridges. Enclosures are small areas that are surrounded by ridges. Bridges are short ridges that connect two other ridges. Ridges crossings are cross ridges each other. Hooks are small ridge that curve back on themselves.






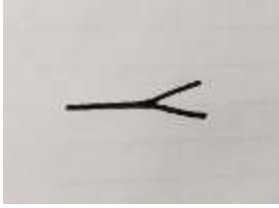

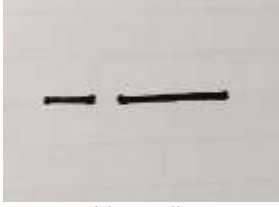

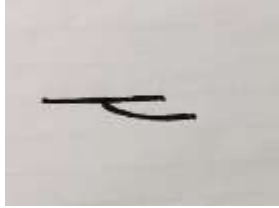

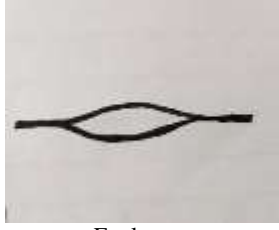

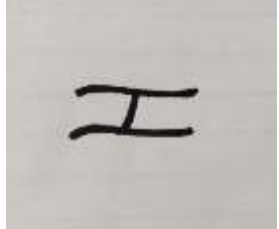


**Fig 2:** Exploring Minutiae in Finger Knuckle Prints: Understanding Patterns and Challenges

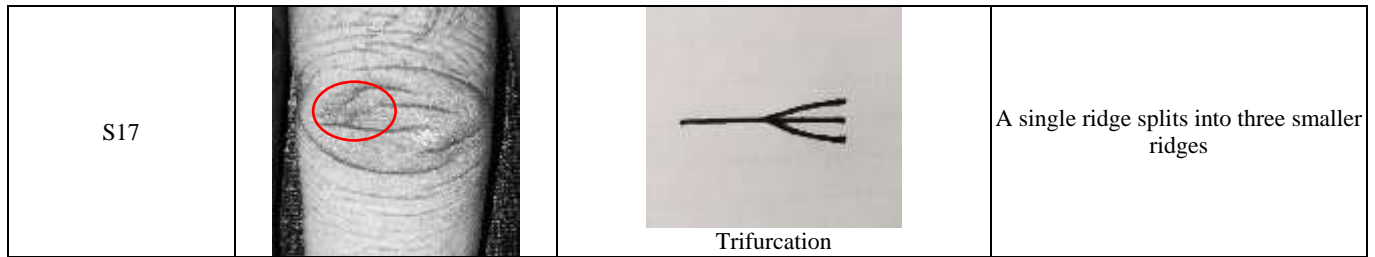
These are the minutiae like trident, trifurcations, opposite trifurcation, opposite bifurcation, angle brackets, infinity, branched, kaph, joint bifurcation is developed. There are the traditional minutiae in knuckle prints which are also found

in fingerprints and are shown in traditional methods earlier. This method is difficult to capture in such situations, where the fingers are heavily worn, injured, have moisture and dusty.



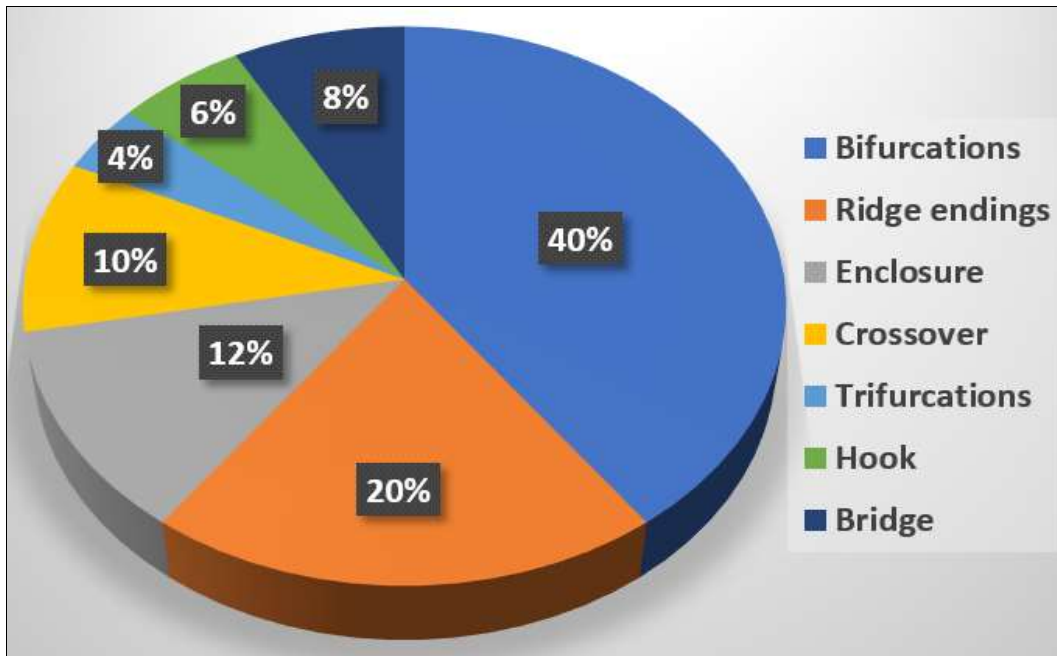
**Table 1:** Showing common traditional minutiae characteristics in knuckle prints

Sample Number	Specimen sample	Minutiae	Minutiae Characteristic features
S02		 Bifurcation	Single ridge divides into two
S15		 Ridge ending	Abrupt ending of ridge
S16		 Hook	Small spur arises from a running ridge
S20		 Enclosure	A single ridge diverges and then converges
S32		 Ridge bridge	Two running ridges are connected by a small intermediate perpendicular ridge.
S16		 Crossover	A connecting friction ridge made up of two bifurcations

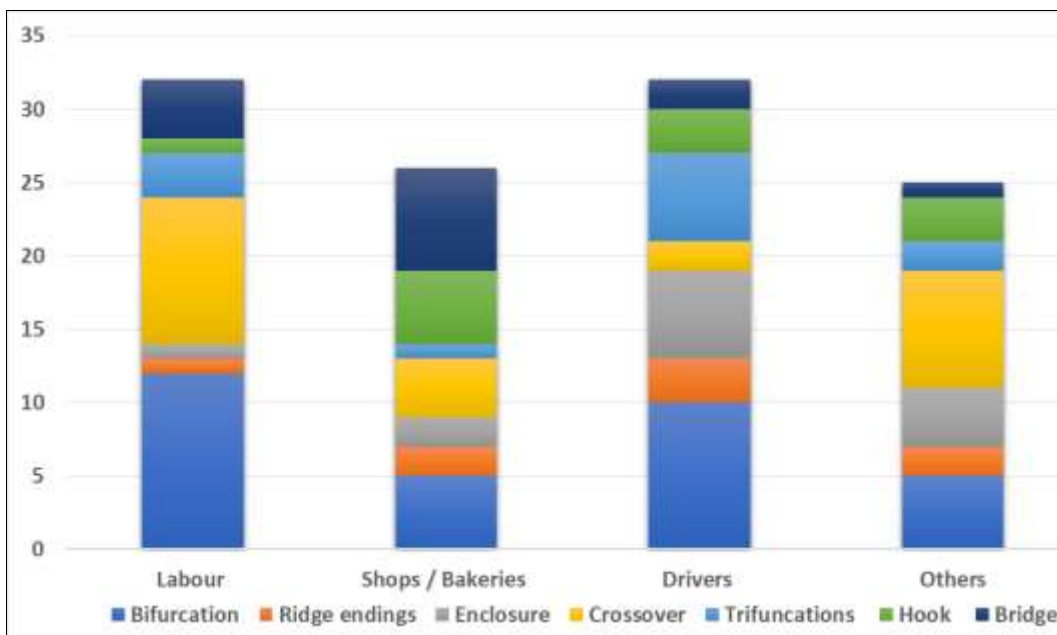


This is the pie chart representing traditional minutiae based on their age and their occupations according to their bifurcations, ridge endings, enclosures, crossover,

trifurcations, hook, bridge. The trifurcations are at a heavy rate that is about 40%, followed by ridge endings which are 20%.



**Fig 3:** Traditional Minutiae found based on Age [above 30 yrs]




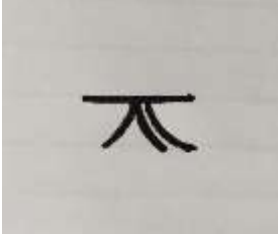

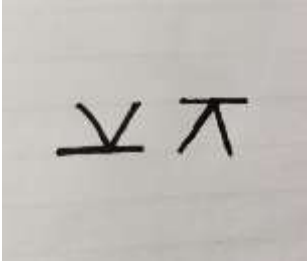

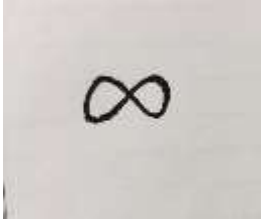

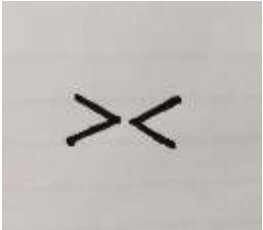






**Fig 4:** Traditional Minutiae found based on Occupations

During the above research it was discovered that finger knuckle prints have some minutiae features like trident, kaph, double bifurcation, trifurcation, joint bifurcation, infinity, angle bracket etc. Knuckle prints are more complex

and intricate patterns to replicate it. They provide crucial evidence to help prove the presence of a specific individual and are used to link a suspect to a crime scene or object.

**Table 2:** Showing some new minutiae characteristics in knuckle prints discovered during the research

Sample Number	Specimen sample	Minutiae	Minutiae Characteristic Features
S03		 Joint bifurcation	Two set of bifurcations running anti parallel to each other connecting at a convergence
S10		 Trident	A single ridge branched with three roots at the medium position.
S14		 Kaph	Two hooks arising from a horizontal running ridge which appears like a Roman alphabet
S23		 Infinity	A ridge that has shape of number eight on its side
S39		 Angle bracket	An opposite directional arrow facing each other at the point of convergence

S41		 <p>Double bifurcations</p>	Ridge splits into two smaller ridges on opposite sides
S48		 <p>Unusual</p>	A prominent ridge leading to its convergent bifurcation at the median position.

In new Minutiae (Above age group 30 years) joint bifurcation, unusual, double bifurcation are maximum as comparison to trident.

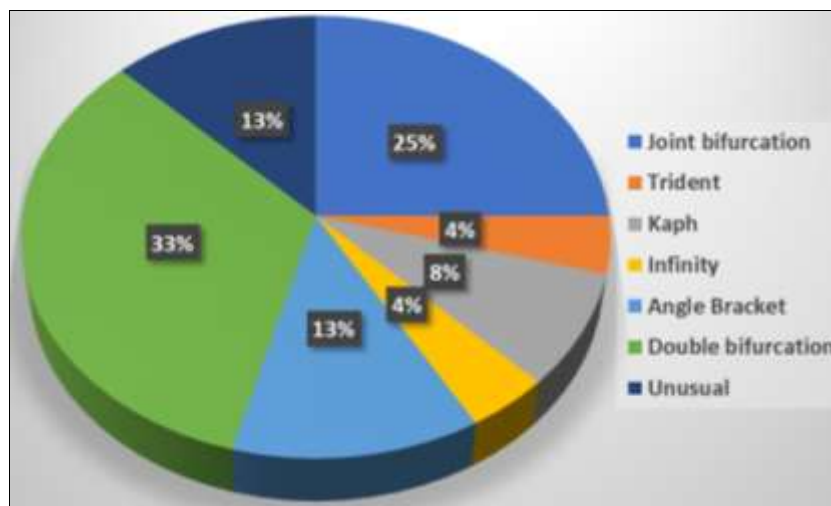


Fig 5: New Minutiae found based on Age [above 30 yrs]

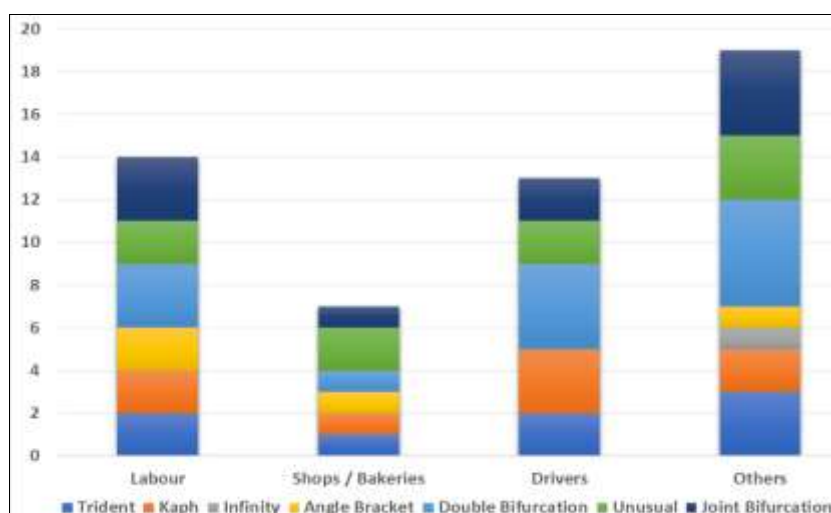


Fig 6: New Minutiae discovered based on occupation

#### 4. Conclusion

Knuckle finger prints are more complex that is much more intricate patterns compared to traditional finger prints and are more difficult to replicate. The unique characteristic elevates the forensic science to help the identification and individualize a particular person based on it.

#### 5. Conflict of Interest

Not available.

#### 6. Financial Support

Not available.

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