COLOUR ATLAS OF FORENSIC TRAUMATOLOGY

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Version 1

Firearm Injuries

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FOREWORD

The greatest pleasure I experience as a teacher, is to see my students excel in their chosen careers and perform even better than myself. The series of e-booklets prepared to better equip medical officers to handle common conditions likely to be encountered in their day to day forensic practice by Professor Dinesh Fernando, is a good example of one of my students doing better than me!

Dinesh is the son of Emeritus Professor of Community Medicine, Former Head, Department of Community Medicine, Former Dean, Faculty of Medicine and Vice Chancellor of the University of Peradeniya, Malcolm Fernando, who was an illustrious medical academic. Following his father's footsteps, he joined the University of Peradeniya in 2003.

Dinesh was one of my post graduate trainees at the Department of Forensic Medicine and Toxicology, Faculty of Medicine, Colombo, and obtained the doctorate in Forensic Medicine in 2003. He underwent post-doctoral training at the Victorian Institute of Forensic Medicine, Melbourne, Australia, with my colleague and contemporary at Guy's Hospital Medical School, University of London, Professor Stephen Cordner. During this period, he served as the honorary forensic pathologist of the Disaster Victim Identification team in Phuket, Thailand following the tsunami, and was awarded an operations medal by the Australian Federal Police.

He has edited, and contributed chapters to, 'Lecture Notes in Forensic Medicine' authored by the former Chief Judicial Medical Officer, Colombo, Dr. L.B.L. de Alwis and contributed to 'Notes on Forensic Medicine and Medical Law' by Dr. Hemamal Jayawardena. He is the editor of the Sri Lanka Journal of Forensic Medicine, Science and Law. Continuing his writing capabilities, he has compiled an important and unique set of e-booklets which will be a great asset to undergraduate and post-graduate students of Forensic Medicine, and also to our colleagues. Its succinct descriptions of complicated medico-legal issues and clear and educational photographs are excellent. It makes it easy for the students to assimilate the theoretical knowledge of each topic as they have been augmented with histories, examination findings, macroscopic and microscopic photographs of actual cases. In some areas, photographs from multiple cases have been included, so that the students can better appreciate the subtle differences that would be encountered in their practice.

I sincerely thank my ever so grateful student Dinesh, for giving me this great honour and privilege to write the foreword.

Professor Ravindra Fernando

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About the authors.....

Dr. Dinesh Fernando is a Senior Professor in Forensic Medicine at the Faculty of Medicine, University of Peradeniya and honorary Judicial Medical Officer, Teaching Hospital Peradeniya. He obtained his MBBS in 1994 with Second class honours from the North Colombo Medical College, Sri Lanka, and was board certified as a specialist in Forensic Medicine in 2004. He obtained the postgraduate Diploma in Medical Jurisprudence in Pathology from London in 2005, and possesses a certificate of eligibility for specialist registration by the General Medical Council, UK. He underwent post-doctoral training at the Victorian Institute of Forensic Medicine, Melbourne, Australia. He has also worked at the Wellington hospital, New Zealand, as a locum Forensic Pathologist and as an Honorary Clinical Senior Lecturer at the Wellington School of Medicine and Health Sciences, University of Otago, New Zealand. He was invited to visit and share experiences by the Netherlands Forensic Institute in 2019. He was conferred a Fellowship by the College of Forensic Pathologists of Sri Lanka in 2021.

Dr. Sarangi Amarakoon was a temporary research assistant at the Department of Forensic Medicine. She obtained her MBBS in 2023 with second class honours from the Faculty of Medicine, University of Peradeniya and Dr. Diniki Agalawatte was a temporary lecturer at the Department of Forensic Medicine. She obtained her MBBS in 2025 with second class honours from the Faculty of Medicine, University of Peradeniya. Dr. Shanika Ekanayake is a temporary lecturer lecturer at the Department of Forensic Medicine. She obtained her MBBS in 2025 with second class honours from the Faculty of Medicine, University of Sri Jayewardhanapura.

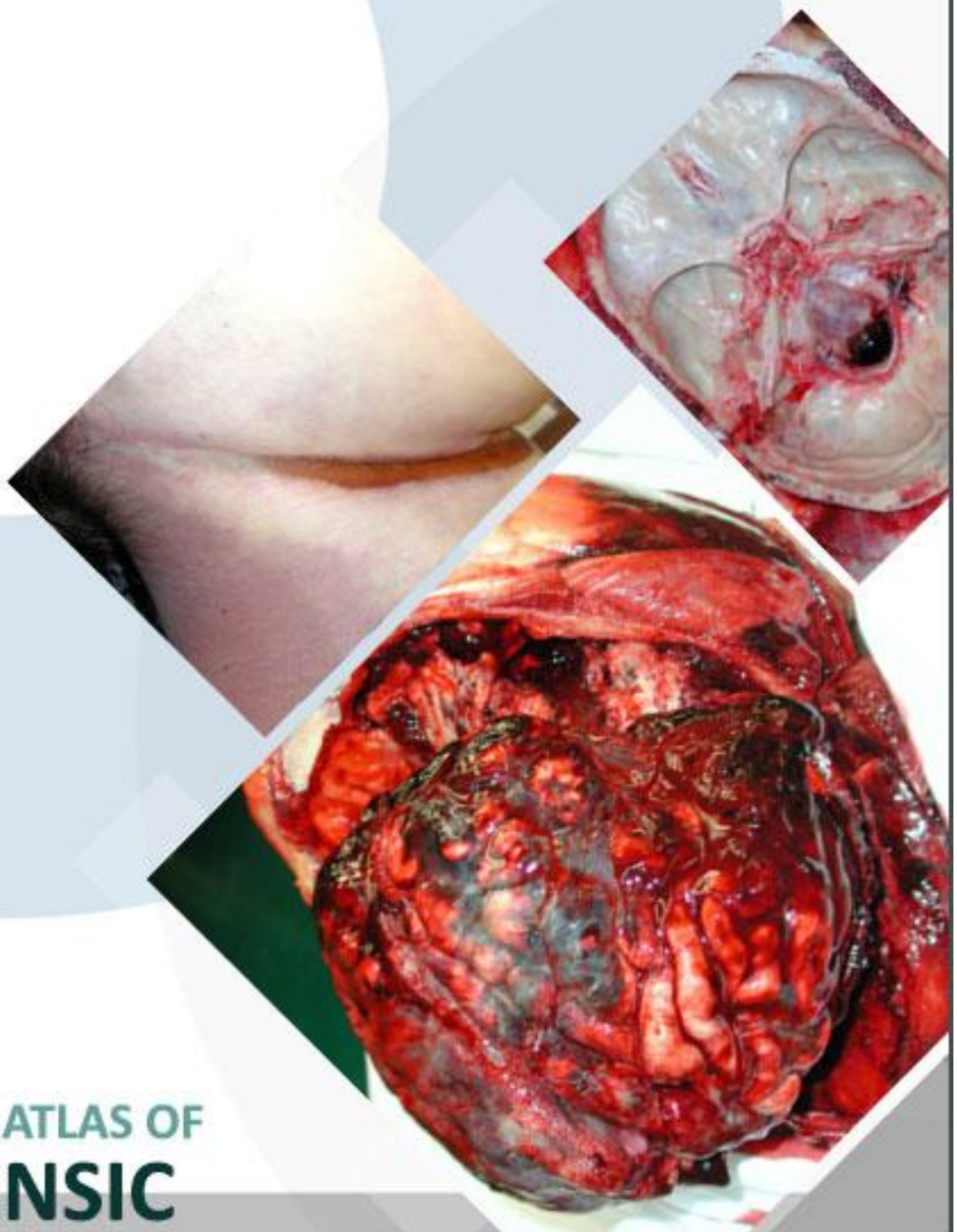
PREFACE

Forensic Medicine in Sri Lanka encompasses, both, examination of patients for medico-legal purposes and conducting autopsies in all unnatural deaths, in addition to those that the cause of death is not known. In the eyes of the justice system in Sri Lanka, all MBBS qualified medical officers are deemed to be competent to conduct, report and give evidence on medico-legal examinations of patients and autopsies conducted by them, as an expert witness. However, during their undergraduate training, they may not get the opportunity to assist, nor observe, a sufficient variety of representative of cases that may be encountered in the future.

Therefore, a series of e-booklets has been prepared to better equip medical officers to handle common conditions that are likely to be encountered in day to day forensic practice. The case histories, macro and micro images are from cases conducted by Prof. Dinesh Fernando. Ms. Chaya Wickramarathne did a yeomen service in the initial designing of lay out and formatting the booklet. The compilation of the case and photographs for publication was initiated by Dr. Sarangi Amarakoon, continued by Dr. Diniki Agalawatte and finalized by Dr. Shanika Ekanayake.

The content herein may be used for academic purposes with due credit given.

Any clarifications, suggestions, comments or corrections are welcome.



COLOUR ATLAS OF

FORENSIC TRAUMATOLOGY

ILLUSTRATIVE CASES

Firearm Injuries

Firearm Injuries

Ballistics is the science that deals with the motion, behaviour, and effects of projectiles, typically bullets or other ammunition. Internal ballistics deals with the behaviour of the projectile inside the firearm. External ballistics deals with the behaviour of the projectile after leaving the firearm. Terminal ballistics looks at what happens when the bullet hits the target**.**

A firearm consists of three main parts which are barrel, action and stock. There are two main types of firearms. Smooth bore weapons have a smooth barrel and fire groups of pellets or shot. Rifled bore weapons have spiral grooves on the inner surface of the barrel and fire single projectiles or bullets. Discharging a smooth bore weapon will result in spreading of the pellets as they travel away from the gun and the larger the pellets spread, larger the area of damage. Pellets are usually found embedded on the victim's body and there's no exit wound unless it is a close range discharge. A bullet fired from rifled weapons, will spin around its own axis. (gyroscopic spin). Bullets almost always cause an exit wound. Air guns are a different group of firearms which use compressed air to propel the projectiles.

The substances like hot gases, flame, smoke and soot, unburnt powder particles, wad and missile released from the barrel will cause a specific pattern around the entry wound. Range of discharge can be estimated by examining the entry wound. Contact wounds are created when the muzzle is held against the body surface and results in a circular entrance wound that approximates the size of the muzzle and may show the outline of the muzzle (muzzle imprint). A little smoke soiling (blackening) may be seen at the margins and the underlying muscle may be cherry pink due to carbon monoxide. A close range discharge will result in a similar entry wound. However, there will be no muzzle imprint, mild pinkish colour, increased 'blackening' and 'powder tattooing' around the entry will be seen. At intermediate range there will be no blackening but tattooing will be increased. In a shotgun spread of the shot will begin at this range causing an irregular rim around the wound giving it a "rat-hole", "cookie cutter" or "Kokis cutter" appearance. At a range of over one meter, burning, blackening, tattooing does not occur. However, an injury on the skin, resembling a 'Maltese cross', caused by the wad, may be seen. At a further distance, satellite pellet holes will be seen around the main central wound.

The direction of the injury is determined by examining the entry wound, exit wound and the track in the body. In rifled weapon injuries, there will be an abrasion collar around the wound caused by the bullet as it goes through the skin. If the bullet enters at 90° to the skin, the abrasion collar will be concentric, but if it enters at an angle, the abrasion collar will be eccentric. Bevelling of the skull helps in determining the path of the bullet. Internal bevelling is seen at the entry wound (the inner table of the skull shows a larger, bevelled-out defect) and external bevelling is seen at the exit wound (the outer table is more extensively damaged and bevelled outward).

History

A 53-year-old female who had a past history of depression, was found in a vehicle with serious injuries to the right side of her head and a shotgun between her legs. At that time the pulse had been present. On admission the deceased had showed minimal signs of life and had been declared dead a few minutes following admission. A suicide note was not recovered from either the house of the deceased, or the vehicle.

External examination

The entry wound was on the right side of the palate. Surrounding this was an area of burning and blackening which extended into the lateral part of the right side of the upper lip. Contusions of the margin of both sides of the lower lip and right side of the upper lip were present. No tear was present at the left angle of the mouth. Extensive fractures and disruption of the right side of the face and lateral aspect of the skull was present. The neck, chest, abdomen, back and extremities were not injured. The palmar and dorsal surfaces of both hands were free of obvious soot.

Internal examination

Musculoskeletal System: Multiple comminuted fractures were present in the right side of the face involving the zygomatic, maxillary, nasal bones and orbit of the face. Fracture of the right anterior cranial fossa and middle cranial fossa was present. A deficiency was present in the right fronto-temporal region. A linear fracture commenced from this deficiency and extended to the right parietal bone. The inner aspect of the vault of the skull did not have pellets embedded, nor were there impressions caused by the pellets. The left frontal bone, the left anterior and middle cranial fossae were intact.

Central Nervous System: Reflection of the scalp revealed sub periosteal haemorrhage in relation to the fractures. No extradural haemorrhage was present. A subdural haemorrhage was present and measured approximately 50-100 ml. Diffuse subarachnoid haemorrhage was present over the convexities of the frontal lobe and the base of the brain. A large laceration was present involving the right frontal lobe and extended from the inferior surface of the frontal lobe through to the upper convexity. The dura and meninges were lacerated in relation to the laceration of the brain. A contusion was present in the left base of the frontal lobe. Multiple cross sections of the brainstem and cerebellum were free of haemorrhages. Multiple sectioning of the cerebral hemispheres revealed intracerebral haemorrhage in relation to the laceration. Five metallic objects measuring 4 mm in diameter (pellets) were retrieved from the brain.

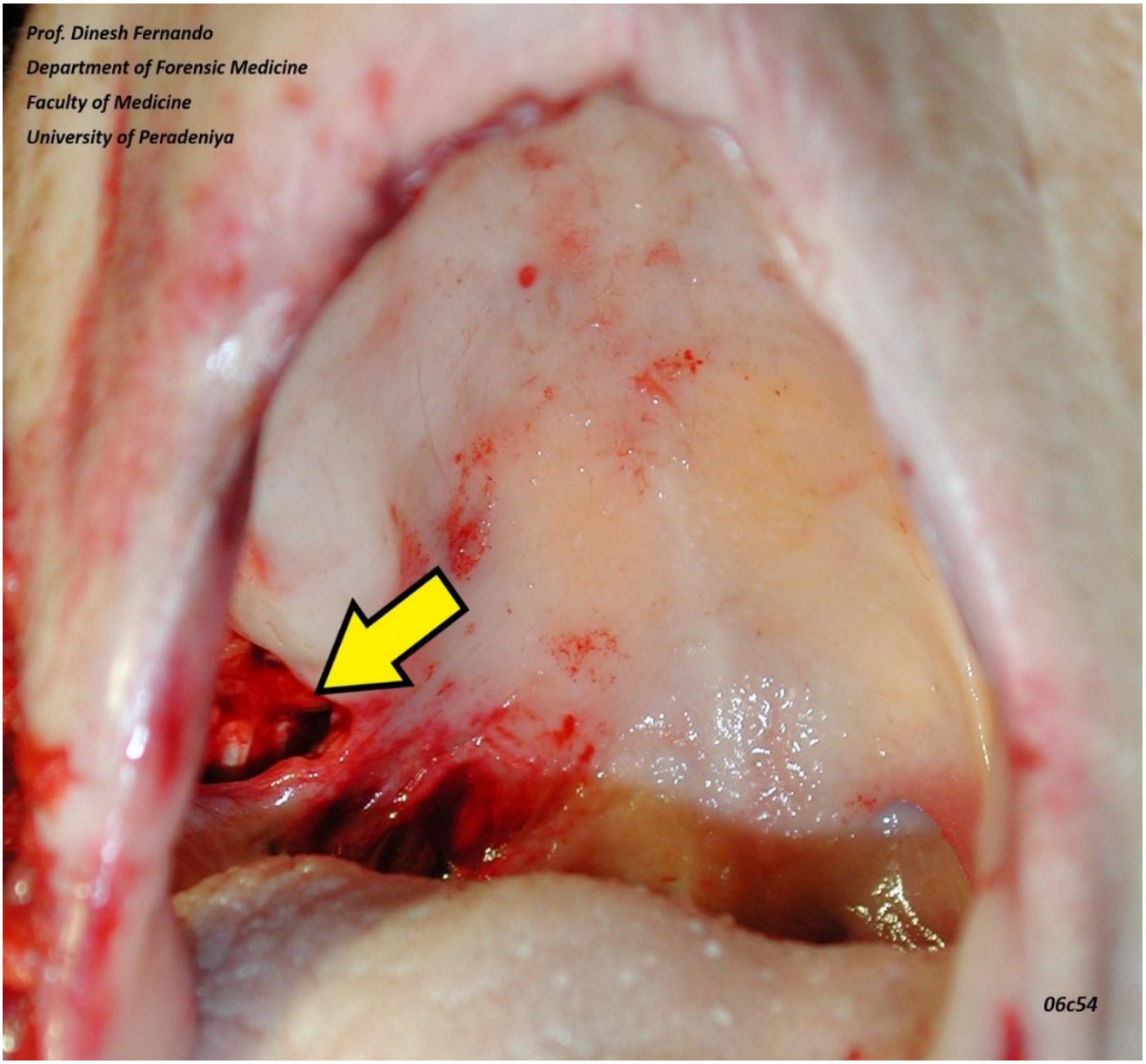


Figure 1: (a) Site of entry on right side of palate in oral cavity.

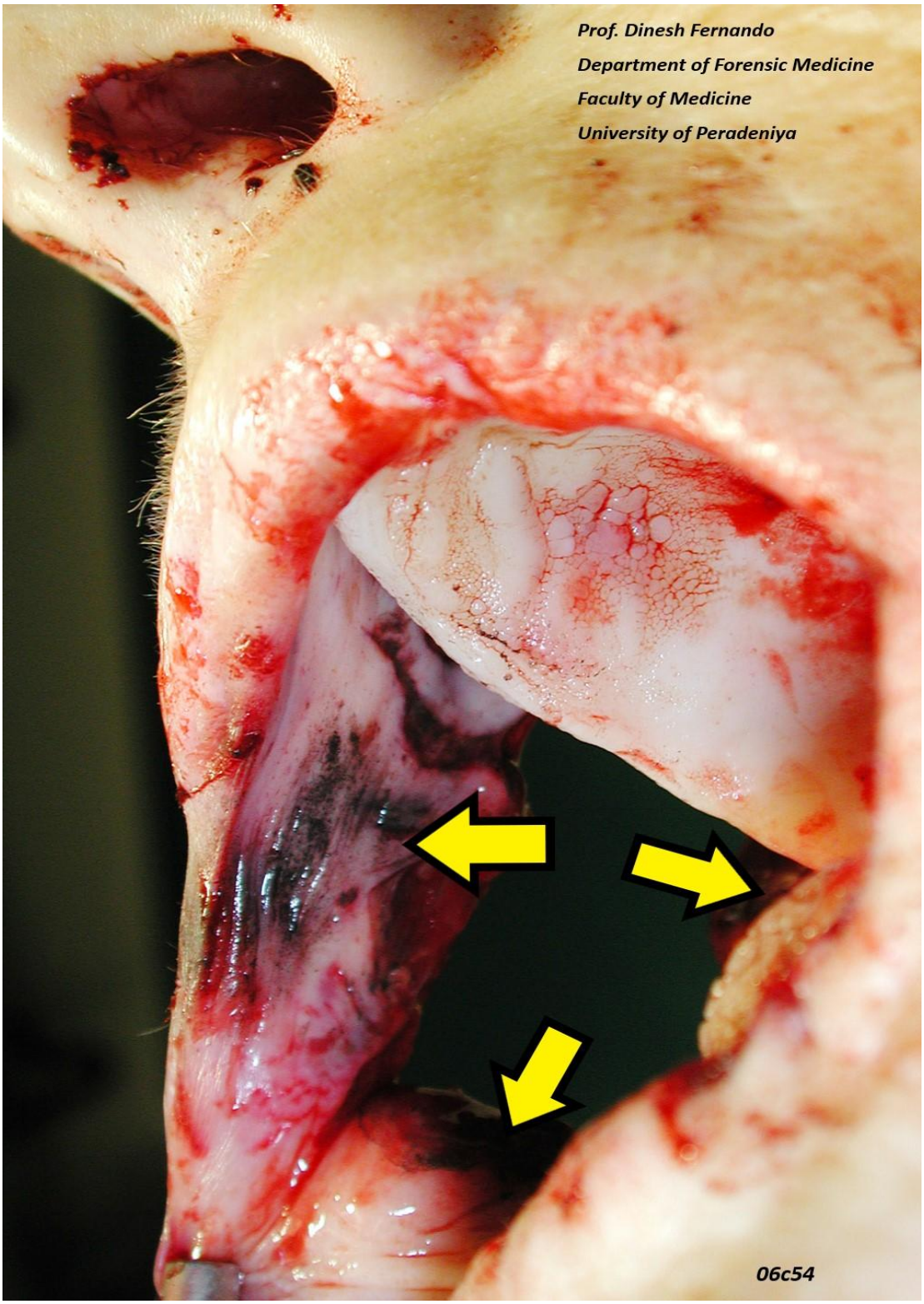


Figure 1: (b) Soot around entry wound on the oral mucosa in the right side of the mouth.

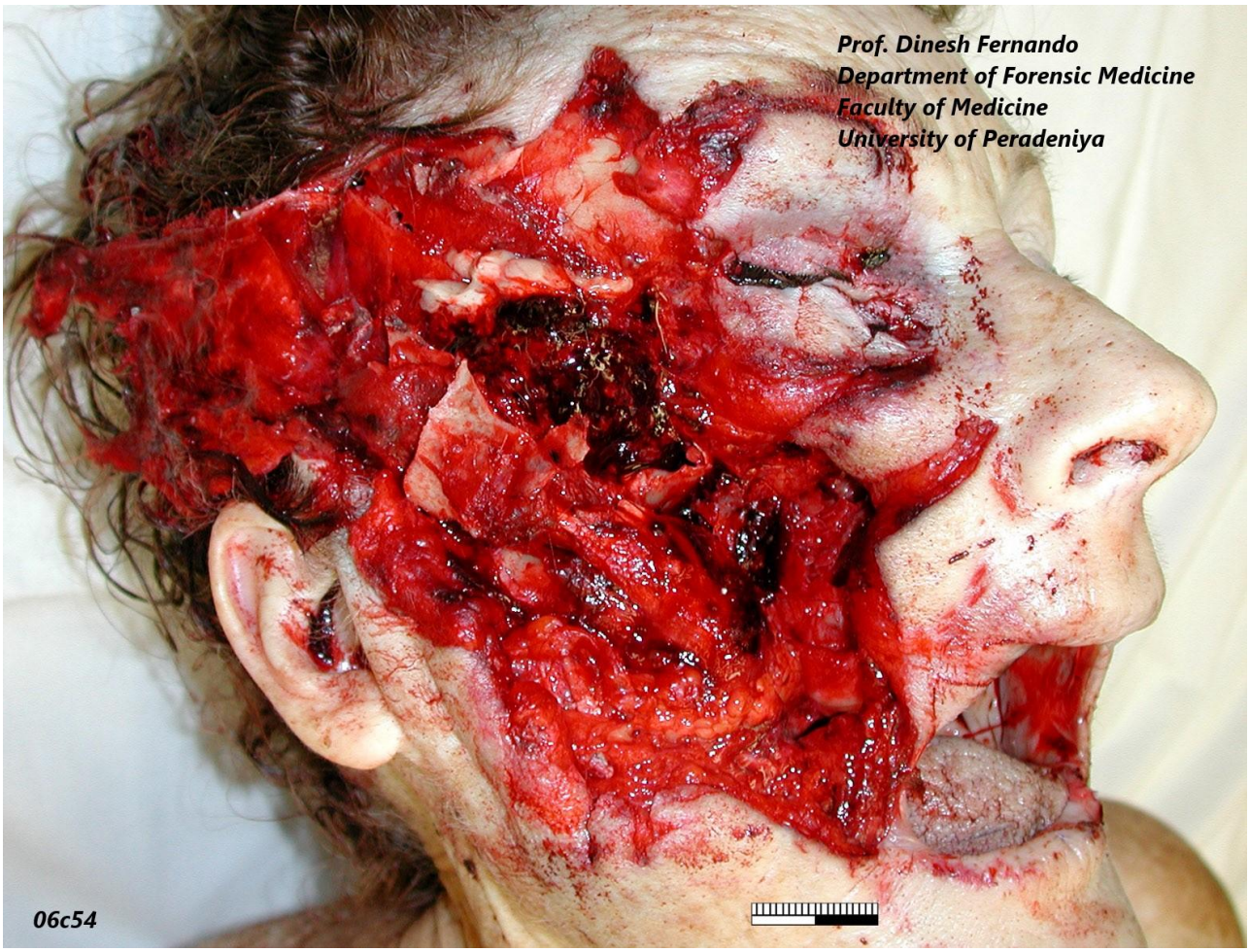
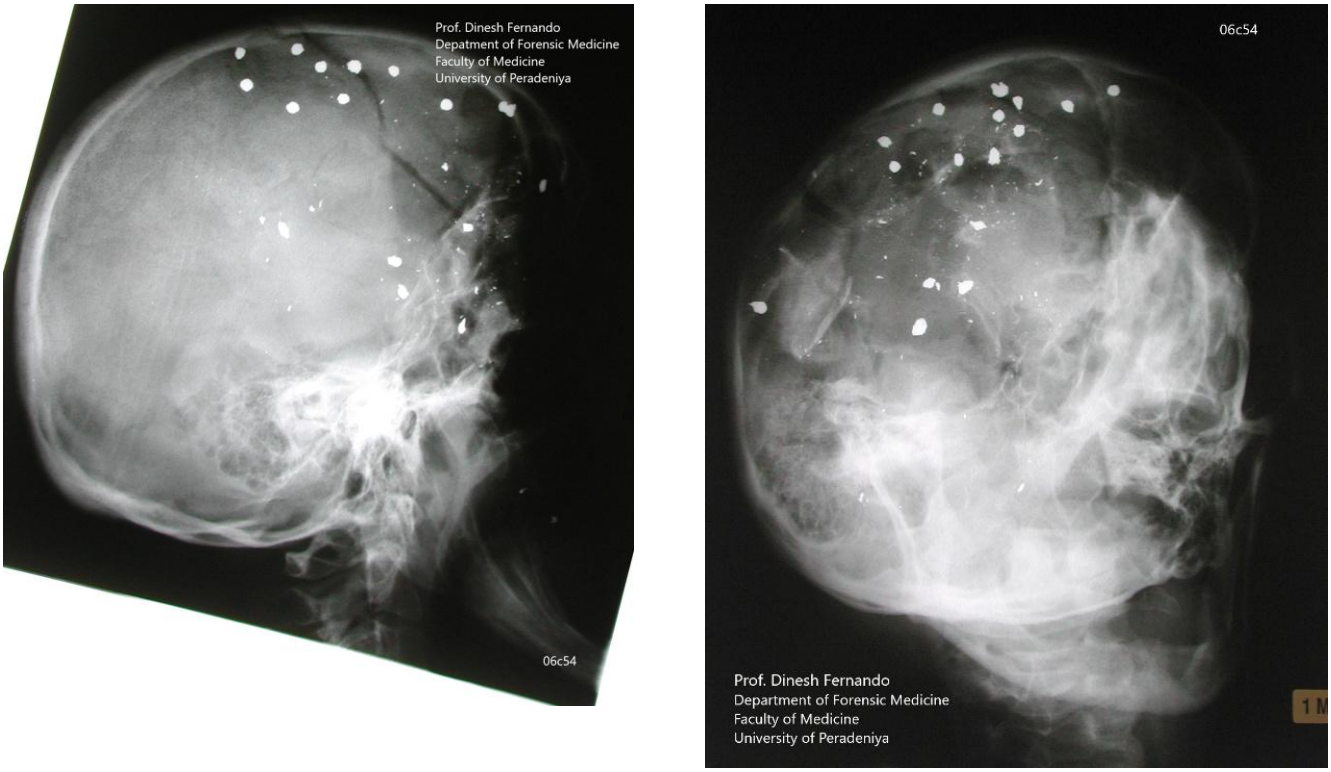


Figure 2: An irregular deficit measuring approximately 130 mm × 50 mm on the right side of the face involving the skin on the temporal and frontal regions of the skull, the right orbit and zygomatic arch, right cheek and right side of the mouth. The margins of skin around the deficit has multiple tears varying from 10 mm to 30 mm in length (stellate deficit).



(a) (b)

Figure 3: X-ray of the skull showed multiple, small, circular, and radio opaque fragments within the calvarium. (a) Lateral view (b) AP view

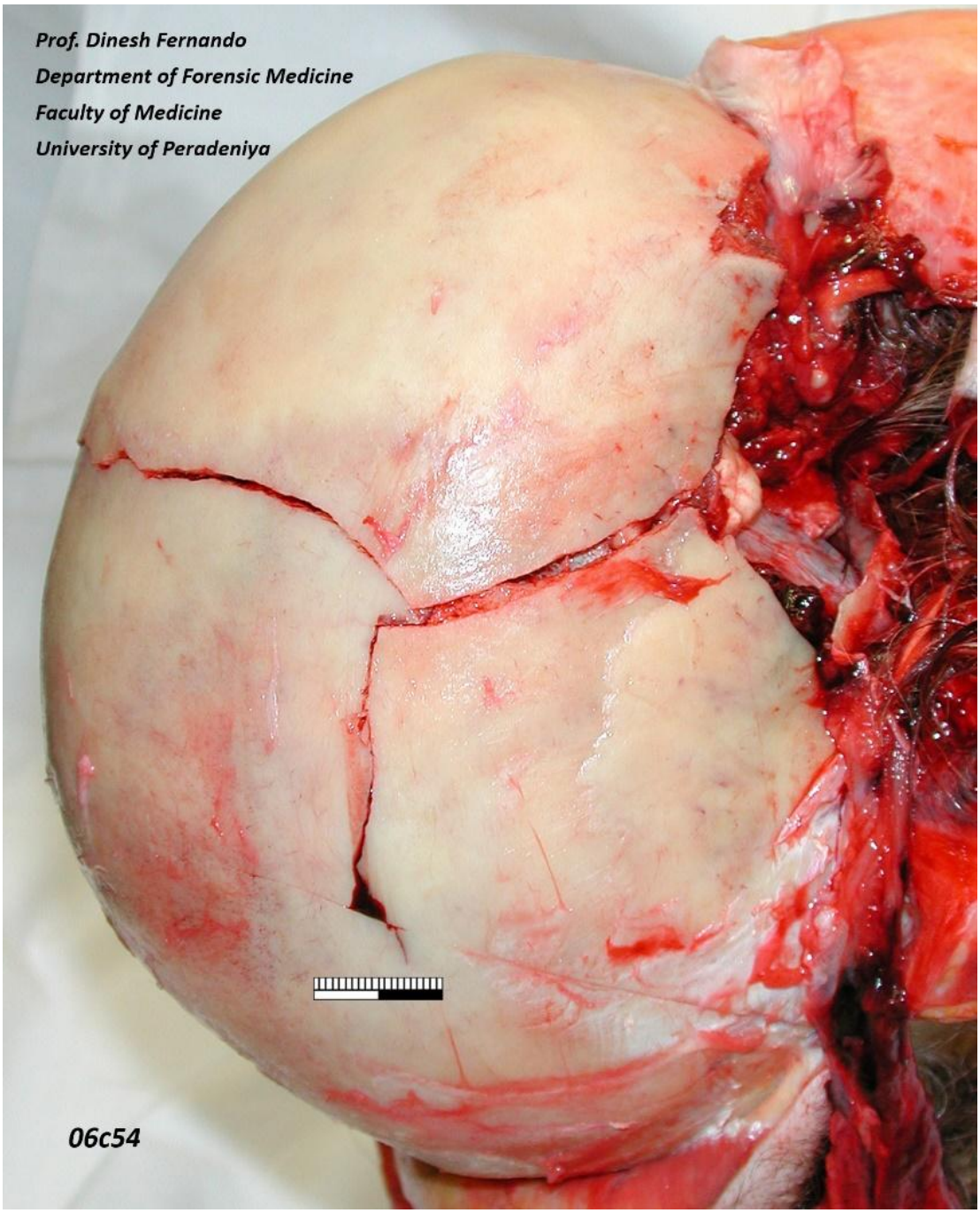


Figure 4: A 50 mm linear fracture extending postero-superiorly from the lateral margin of the right orbit to the right parietal bone. The fracture divided into two with one limb extending transversely posteriorly for 50 mm in the right parietal bone whilst the other limb extended just behind the fused coronal suture and parallel to it for 130 mm. It crosses the midline and extended into the left parietal bone.

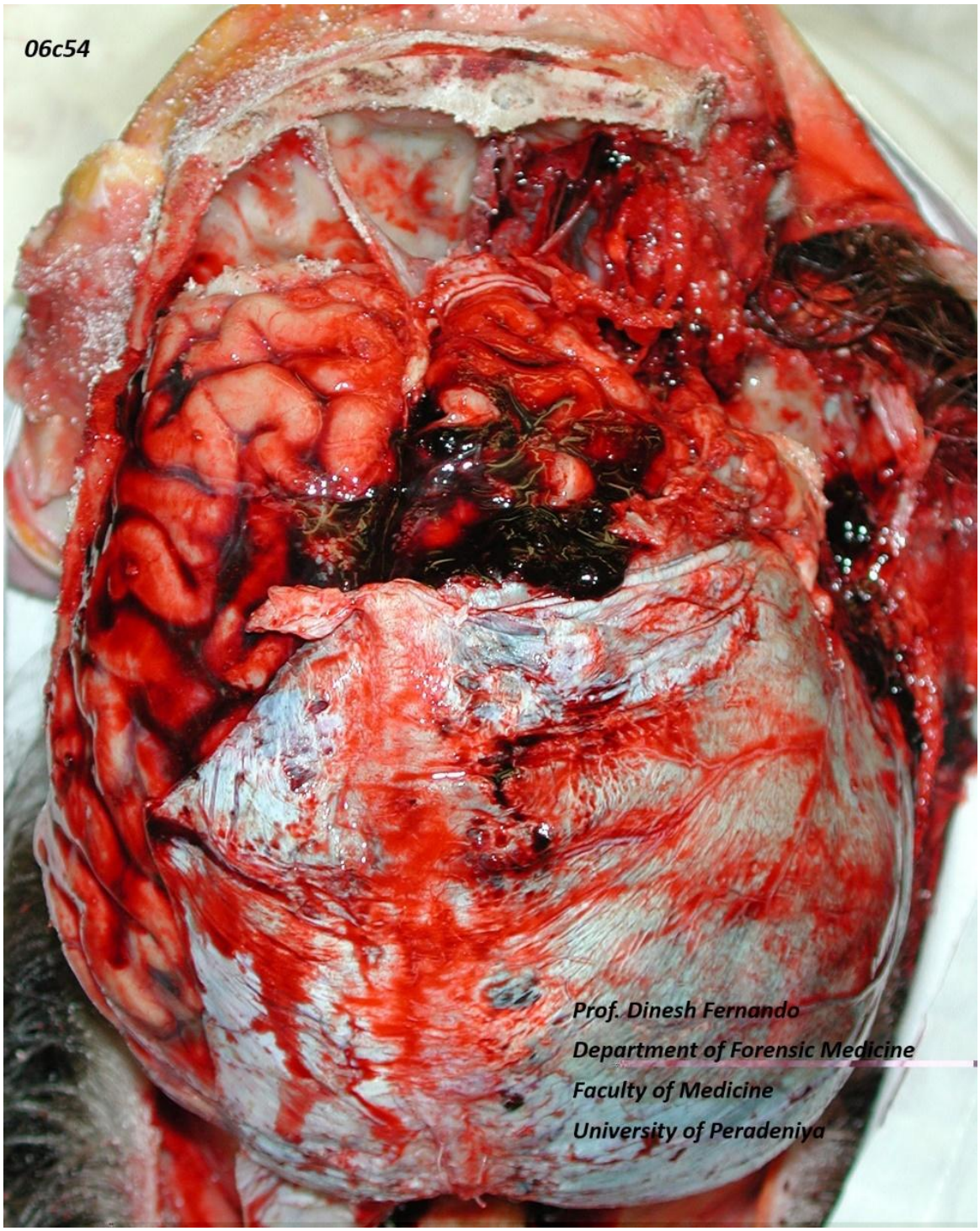


Figure 5: Small subdural haemorrhage of 50–100 ml.

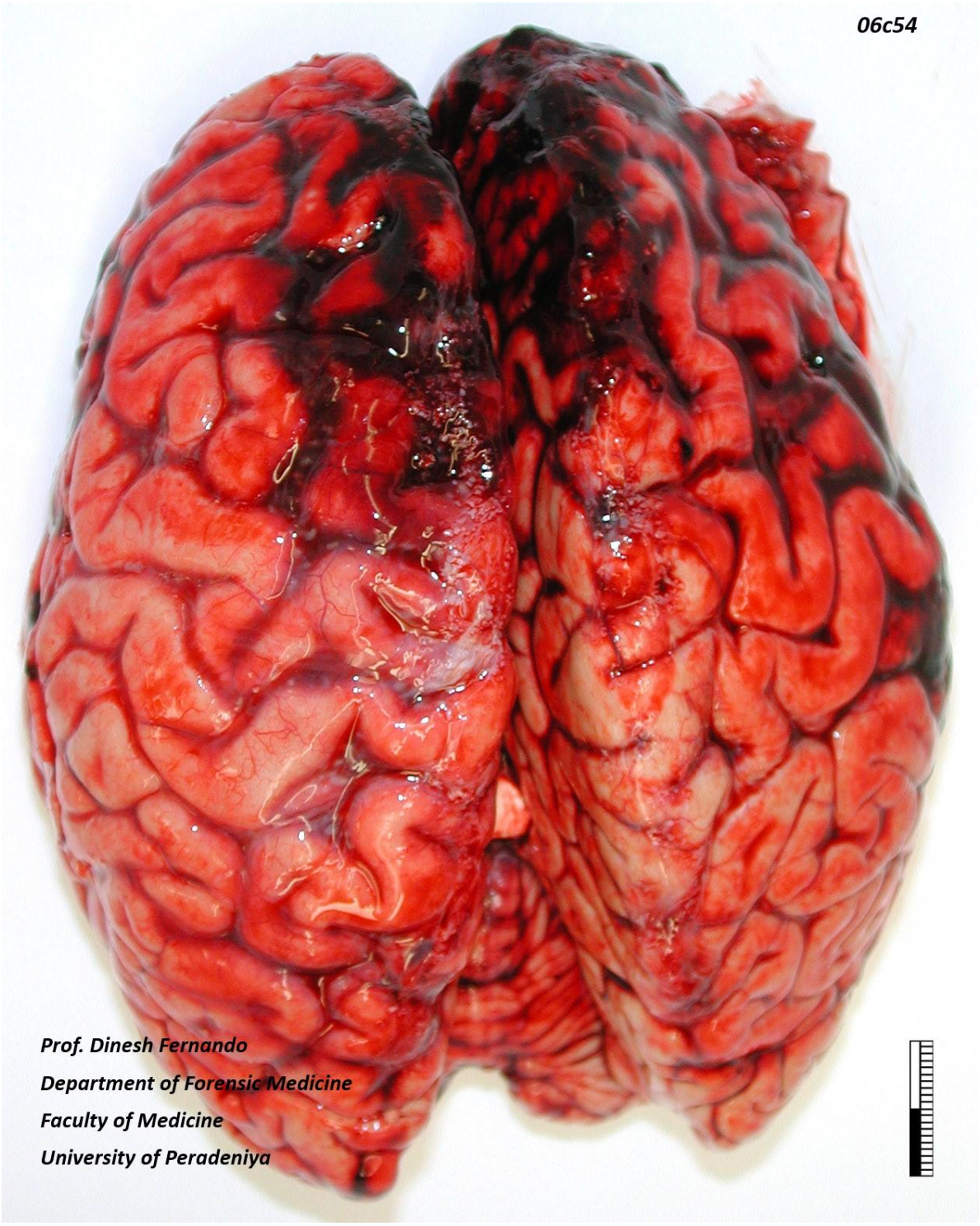


Figure 6: Diffuse subarachnoid haemorrhage over the convexities of the frontal lobes. (Right more than left).

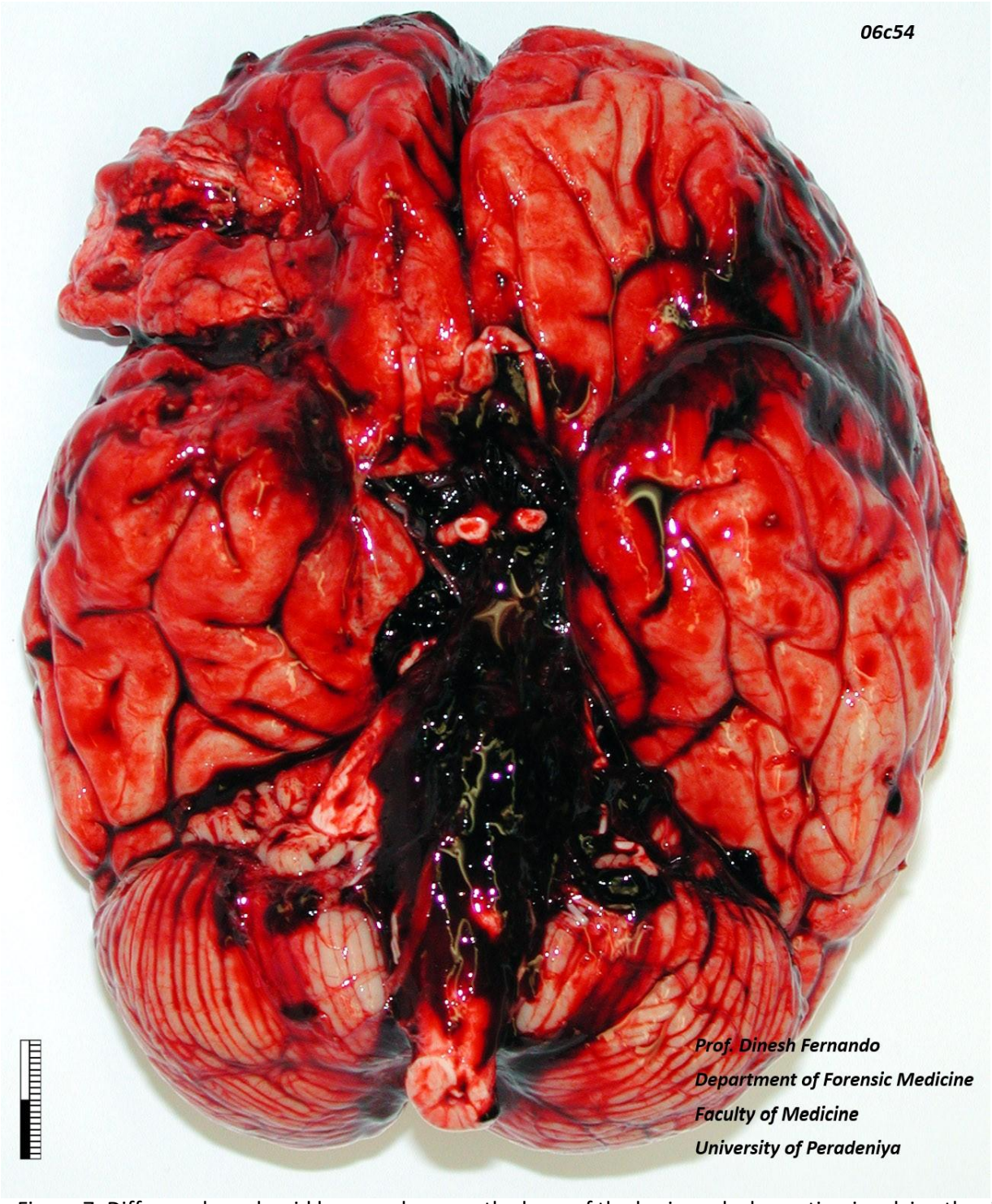


Figure 7: Diffuse subarachnoid haemorrhage on the base of the brain and a laceration involving the right frontal lobe which extends from the inferior surface of the frontal lobe through to the upper convexity.

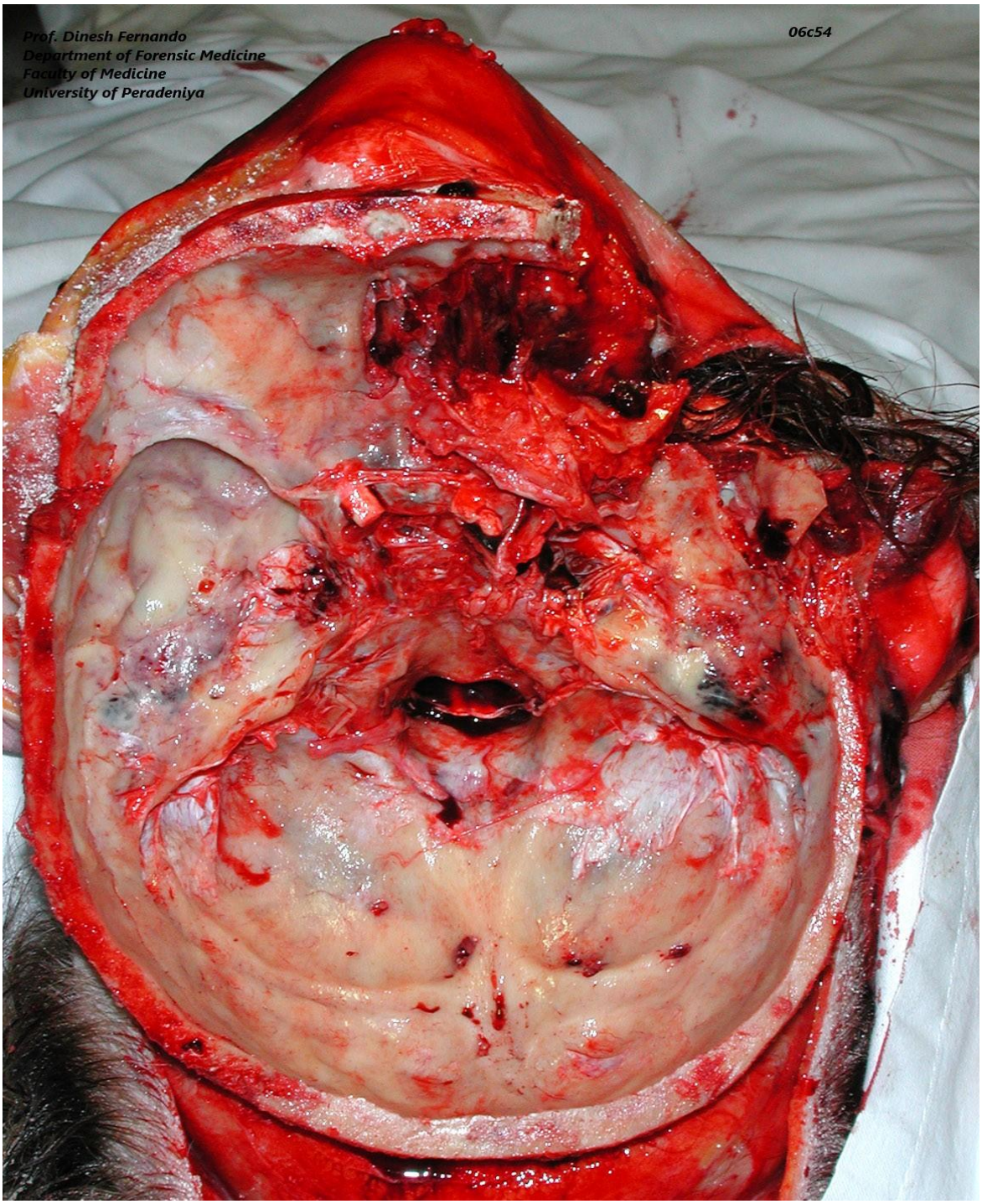


Figure 8: Fracture of the right anterior and middle cranial fossae with a deficiency in the right fronto-temporal region. The left frontal bone, the left anterior and middle cranial fossae are intact. The inner aspect of the vault of the skull did not have pellets embedded, nor were there impressions caused by pellets.

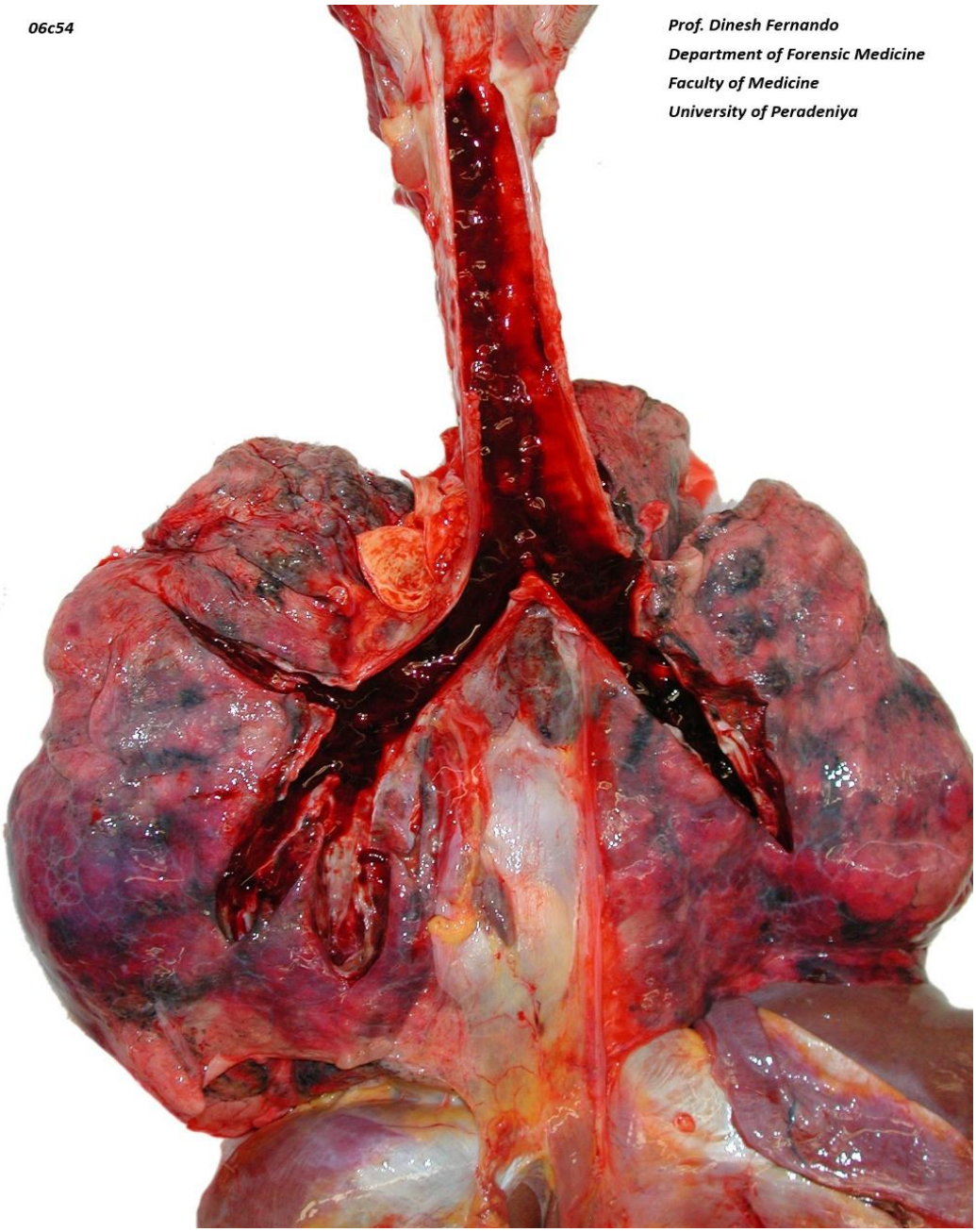


Figure 9: Aspirated blood within the trachea and bronchi. Note the sub pleural haemorrhage.

Cause of death

Cranio-cerebral injuries due to contact range discharge of a smooth bore firearm within the oral cavity.

History

A 29-year-old male, who had a history of bipolar affective disorder shot himself through the head using a 9 mm semiautomatic pistol in front of a witness. The Glasgow coma scale was 6 on arrival at the hospital. Following CT head, surgical debridement of wounds with removal of bone fragments was carried out. A small wound had been noted on the left side, and a large wound on the right side, of the head. He remained in the ICU until the time of his death five days later.

External examination

Bilateral periorbital contusions were present. No injuries were noted in the oral cavity. The neck, chest, abdomen, back and extremities were unremarkable. Multiple, stapled wounds were present on the scalp.

Central Nervous System: Extensive scalp contusion, bilateral temporalis muscle contusions and subgaleal haematoma was present. Subdural and subarachnoid haemorrhages present. Both frontal lobes were extensively lacerated and patchy haemorrhage was present throughout the white matter. The intracranial vessels were unremarkable. Multiple cross sections of the brainstem and cerebellum were unremarkable. Stripping the dura from the skull and calvarium revealed bilateral anterior cranial fossa fractures and right sided middle cranial fossa fracture. The cervical spine was grossly intact.

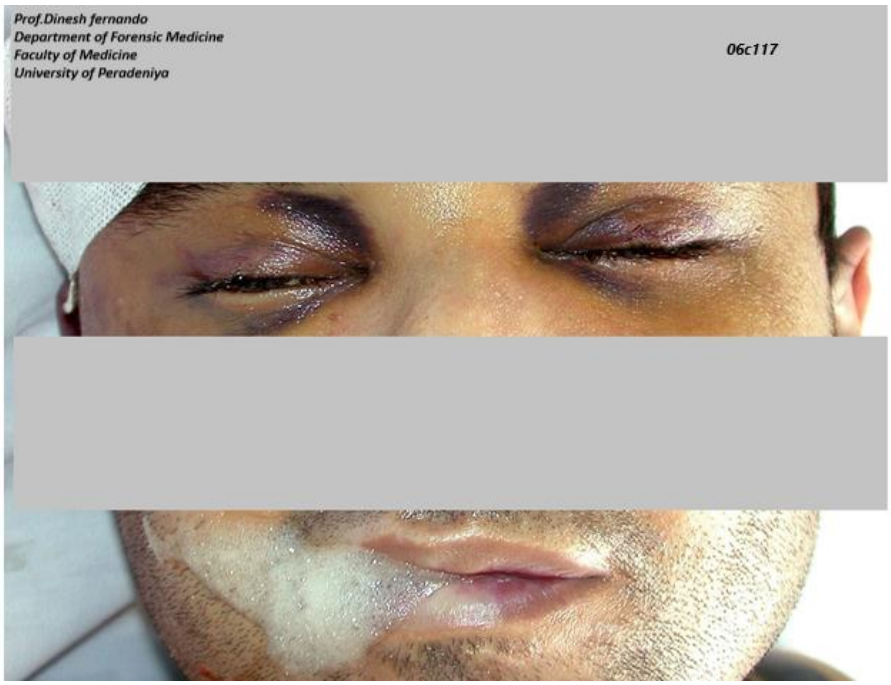


Figure 10: Bilateral periorbital contusions and fine white froth exuding from the mouth.

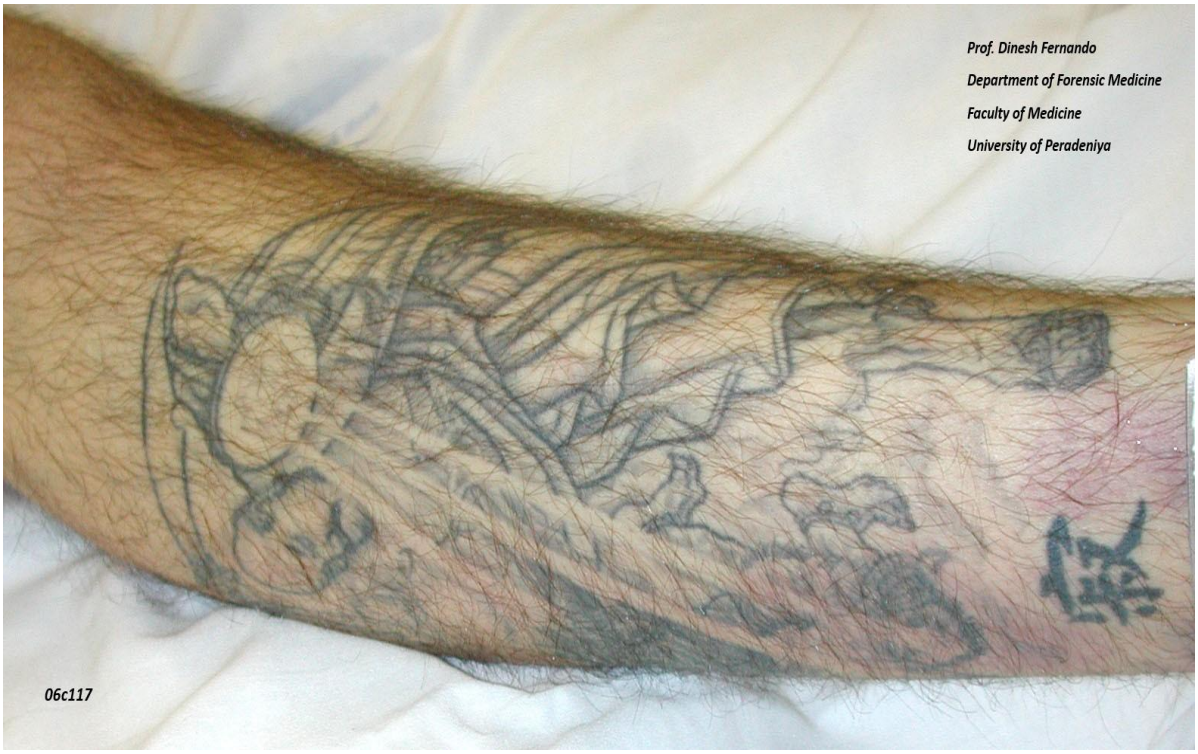


Figure 11: Tattoo on the lateral aspect of the right leg.

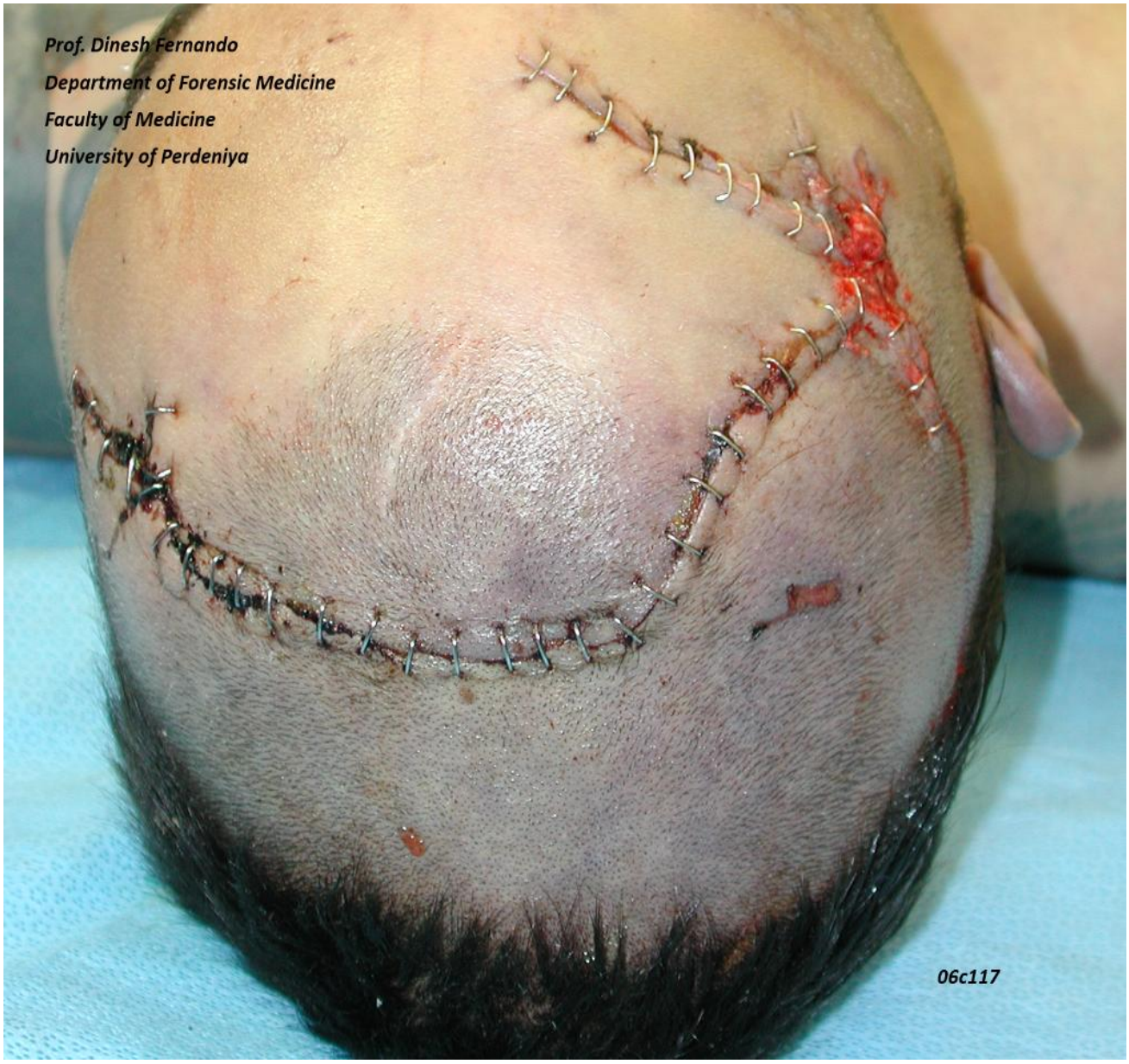


Figure 12: A stapled, stellate shaped laceration in the right temporal region with the midpoint situated 80 mm above the root of the ear, 50 mm posterior to the lateral end of right eyebrow and 80 mm lateral to the midline. The laceration consists of five limbs with longest extending from right temporal to left parietal region. Note the 20 mm scar on the frontal region.

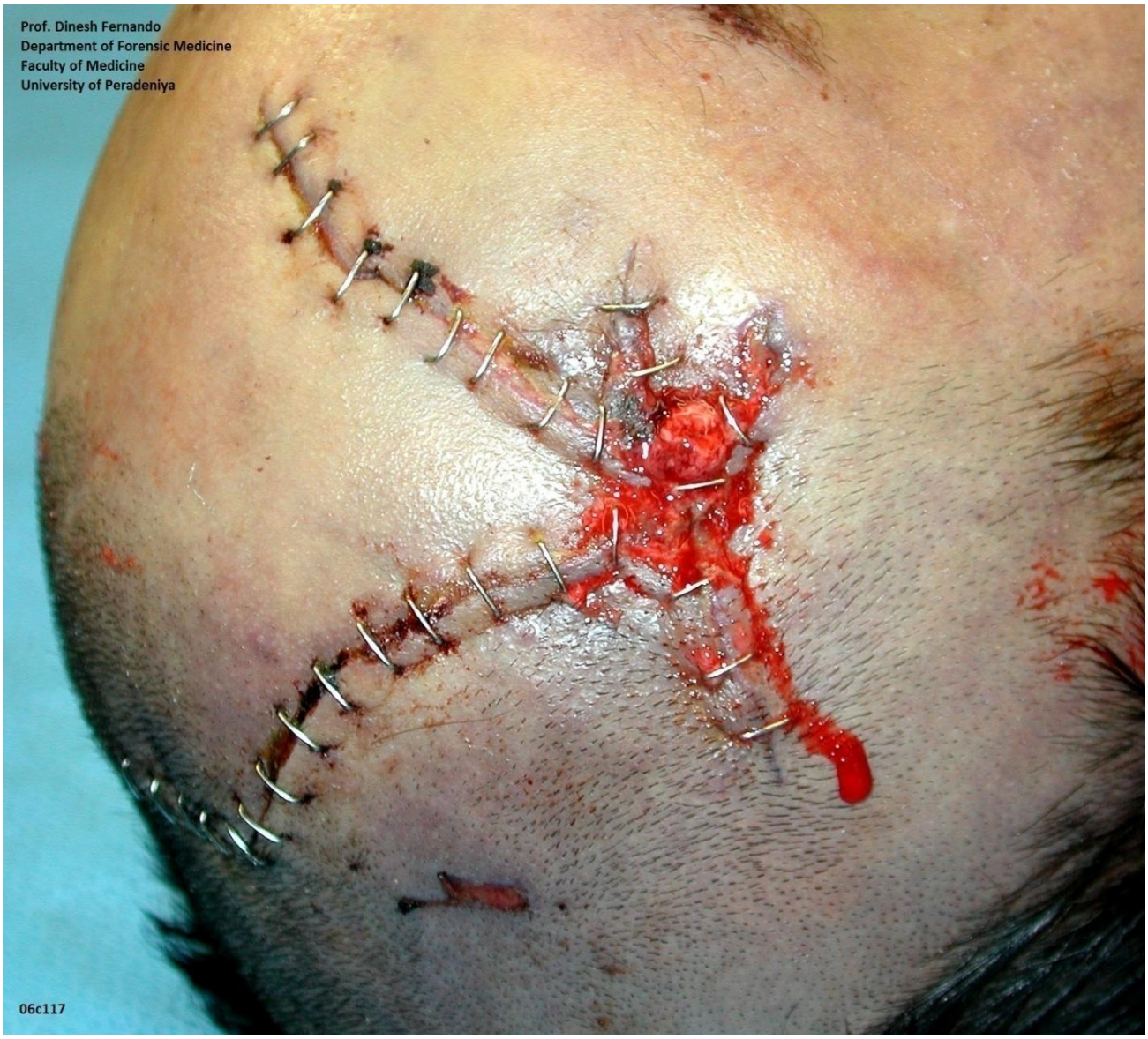


Figure 13 (a): Stellate shaped stapled laceration in the right temporal region consisting of 5 limbs.

Limb 1: laceration extending postero-laterally for 20 mm

Limb 2: laceration extending anteriorly for 20 mm

Limb 3: laceration extending antero-medially for 15 mm.

Limb 4: laceration extending medially for 60 mm

Limb 5: laceration extending postero-medially and included in the surgical incision which crosses the midline and extends to the injury on the left parietal region.

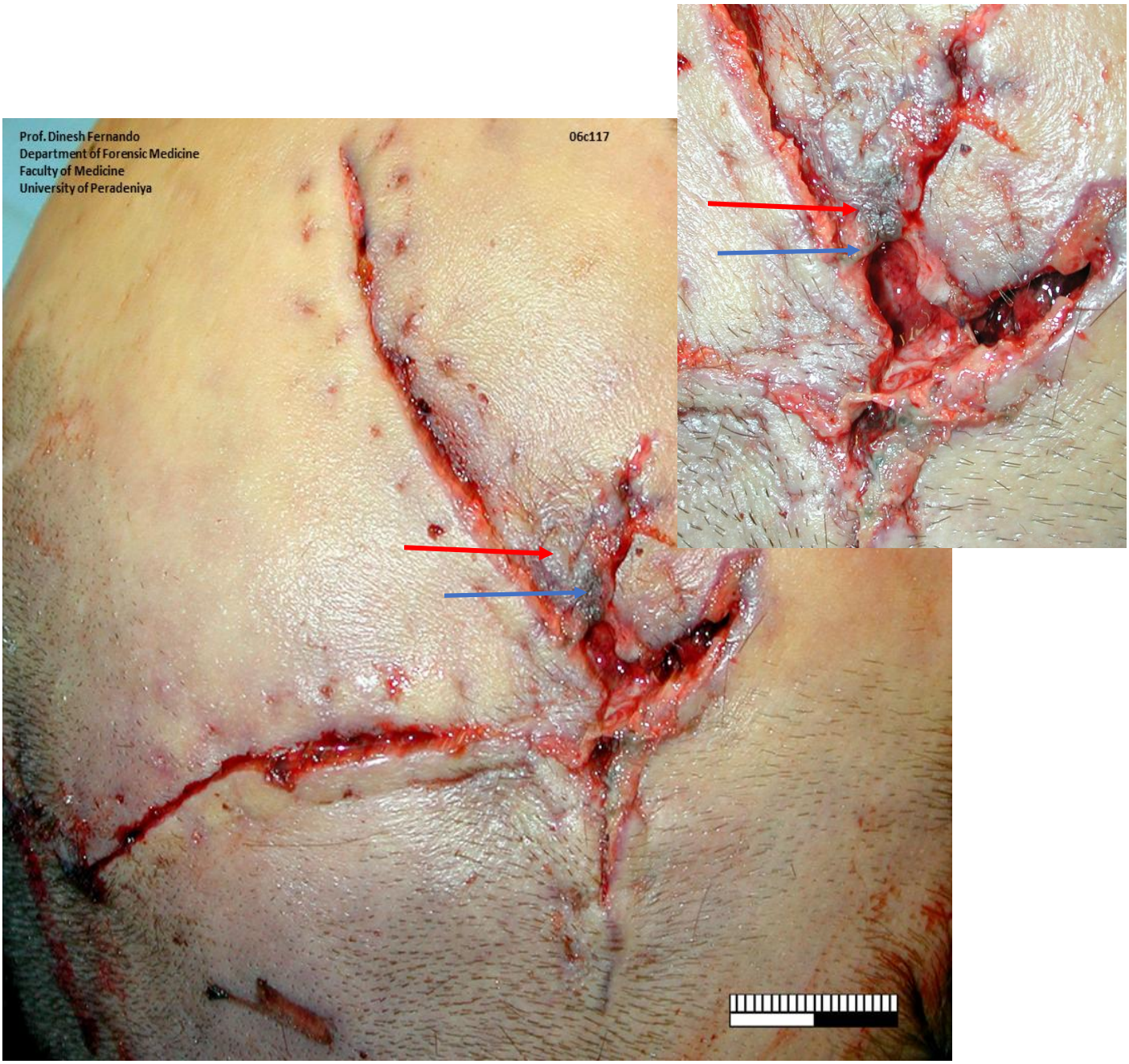


Figure 13: (b) Staples removed. Note the circular deficiency of skin measuring 5 mm in the centre of the laceration (blue arrow). A small tag of skin on the anteromedial aspect of the deficit which was blackish in colour (red arrow) was thought to be soot and examined microscopically. Gunshot residue in the epidermis and dermis associated with haemorrhages, inflammation and necrosis was seen.

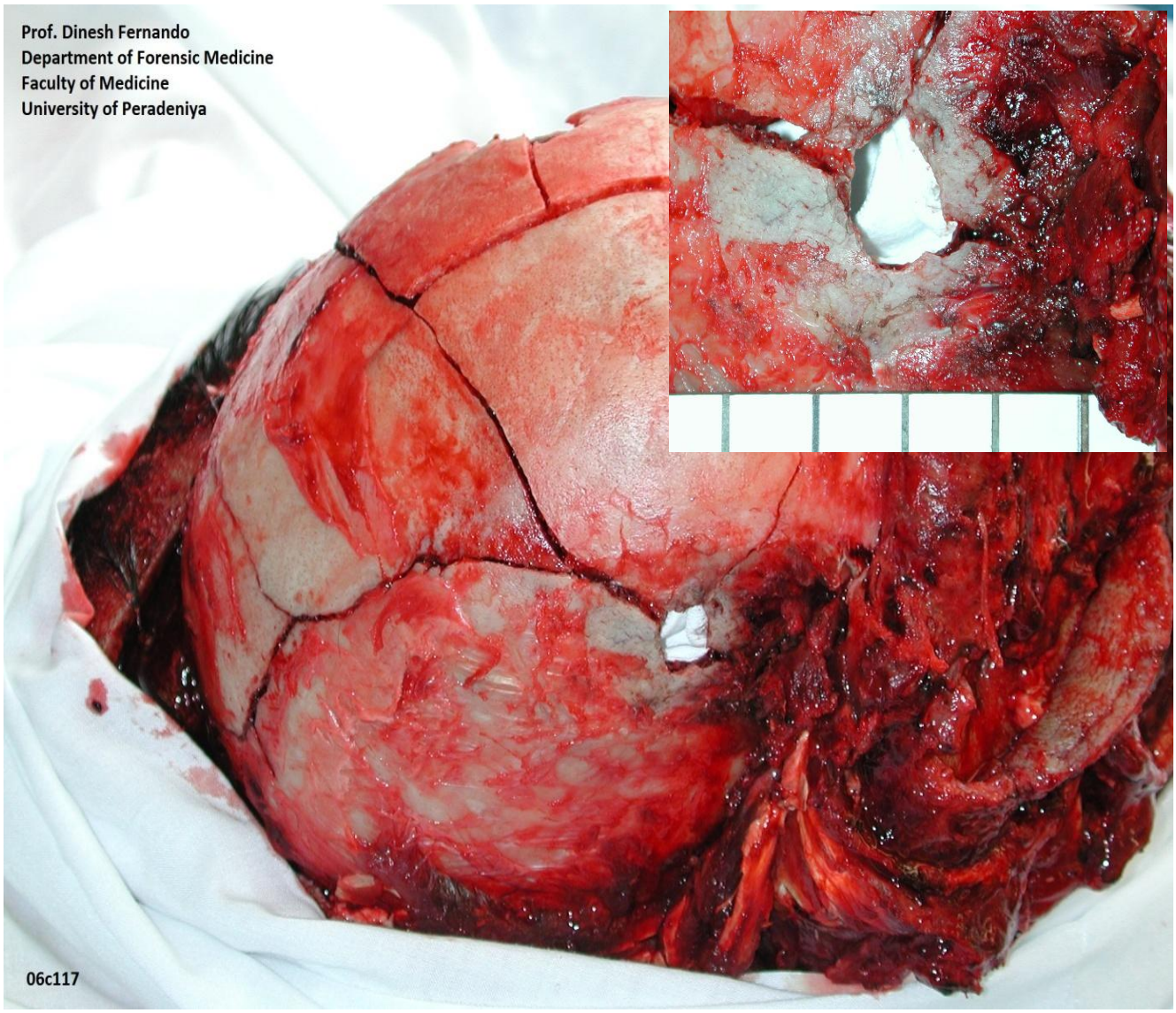


Figure 14: Circular deficit measuring 9 mm in diameter on the right side of the skull with no bevelling seen on the outer table. A linear fracture which extended postero-medially from this defect, branched into two limbs. One limb extended posteriorly while the other continued postero-medially to the left parietal bone. Another linear fracture extended antero-medially from the bony defect to the frontal bone. The third linear fracture from the bony defect extended inferiorly into the right middle cranial fossa.

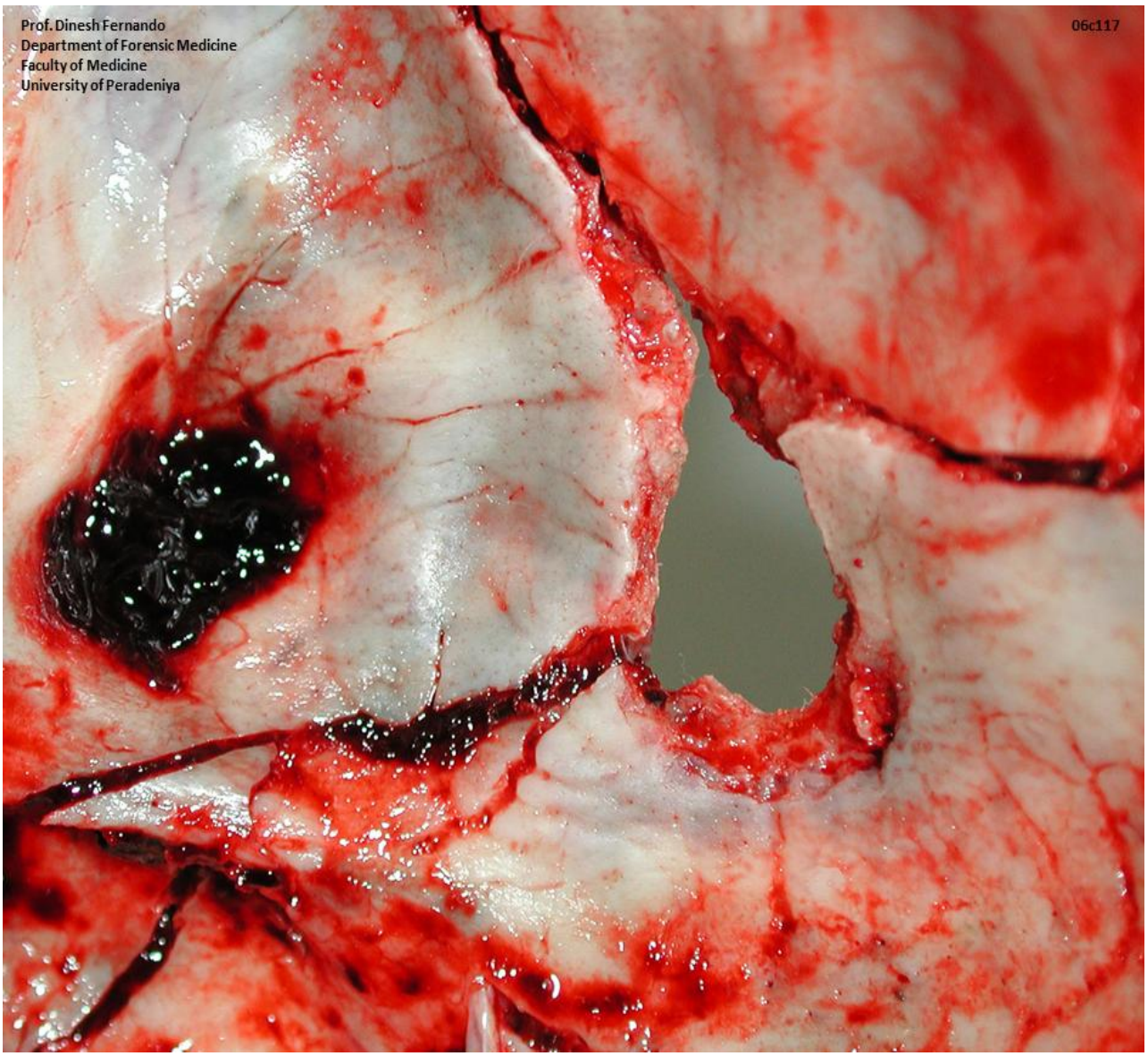


Figure 15: Inner aspect of the skull on right side showing inner bevelling.

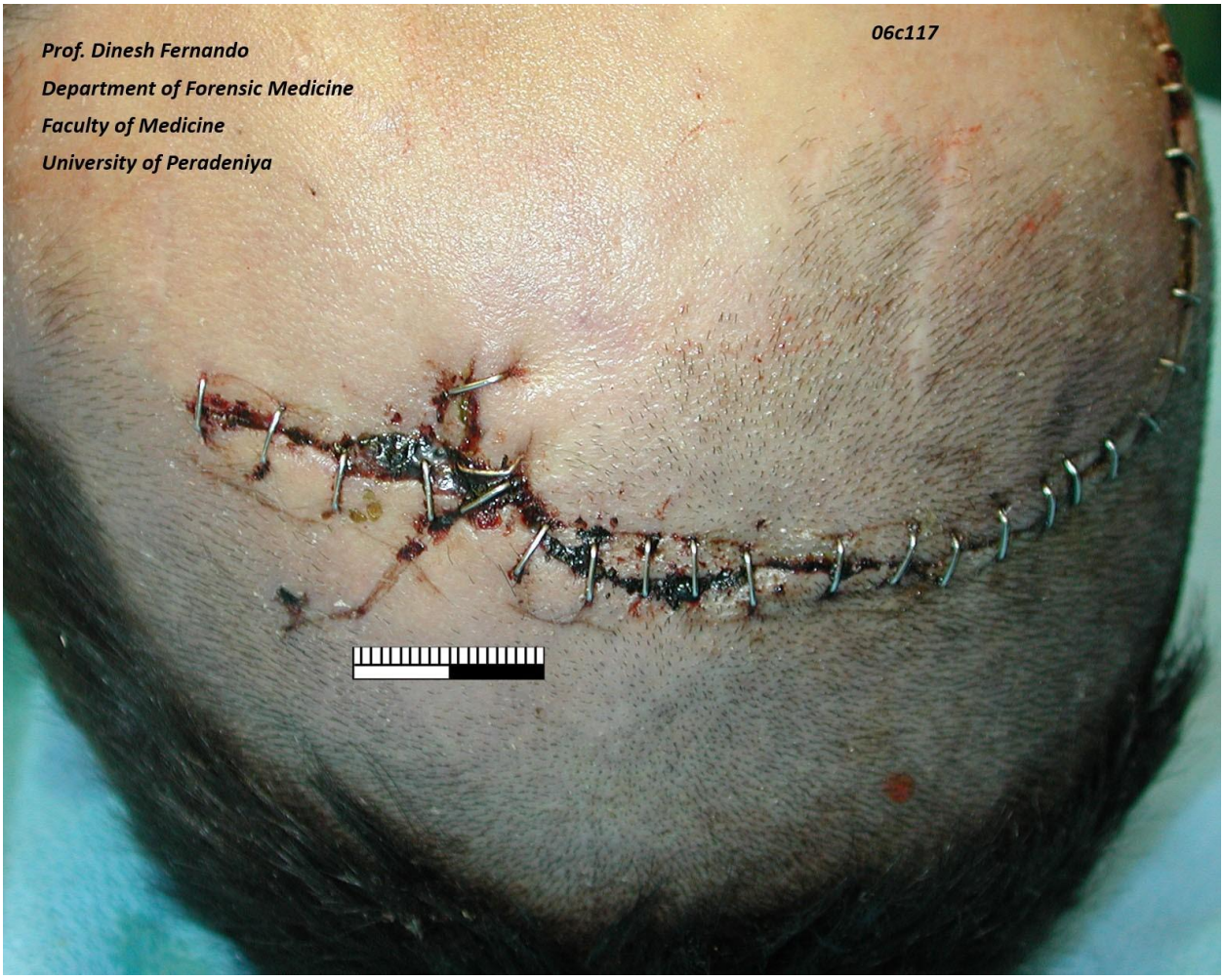


Figure 16: (a) Stapled stellate shaped laceration with three limbs on the left parietal region.

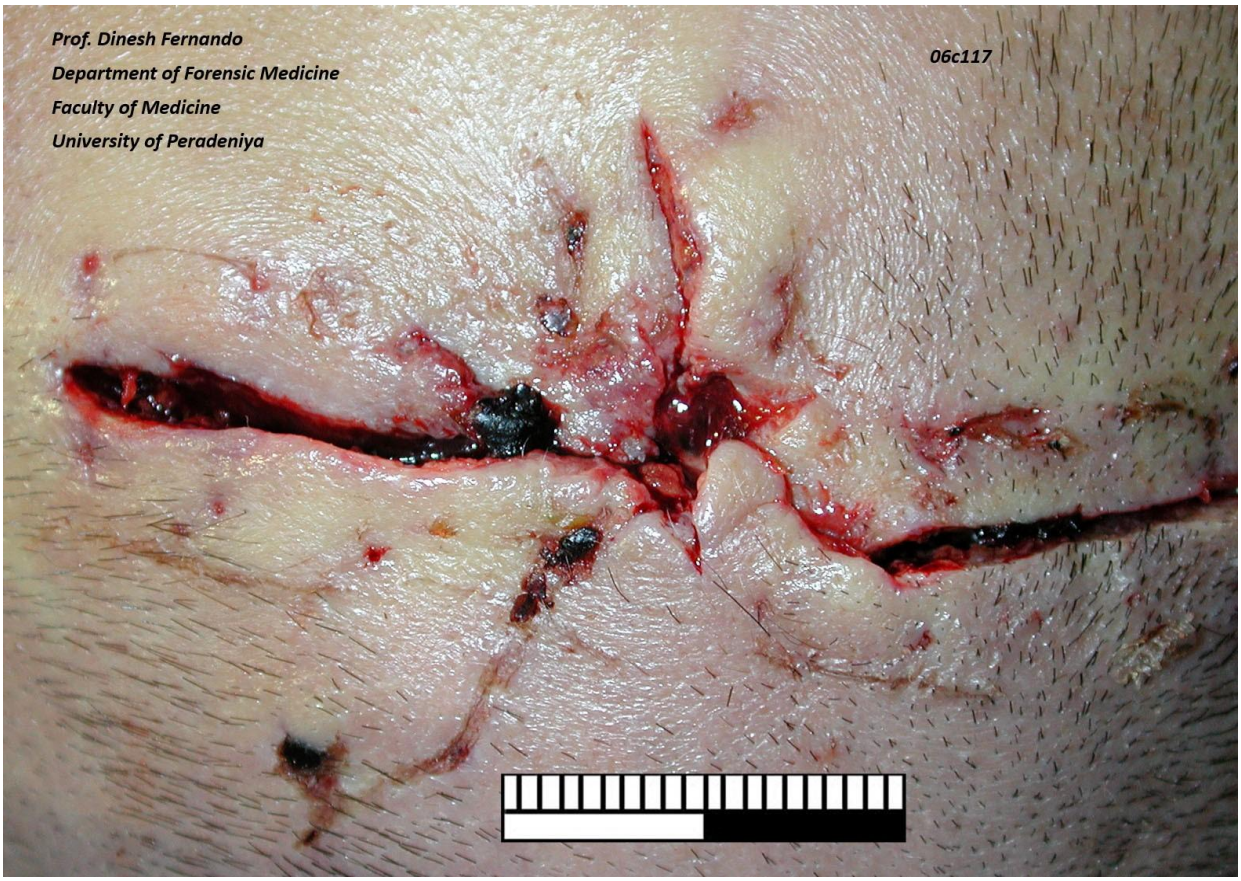


Figure 16: (b) Staples removed from the right sided injury. Skin around this injury was analysed. No gunshot residue was detected.

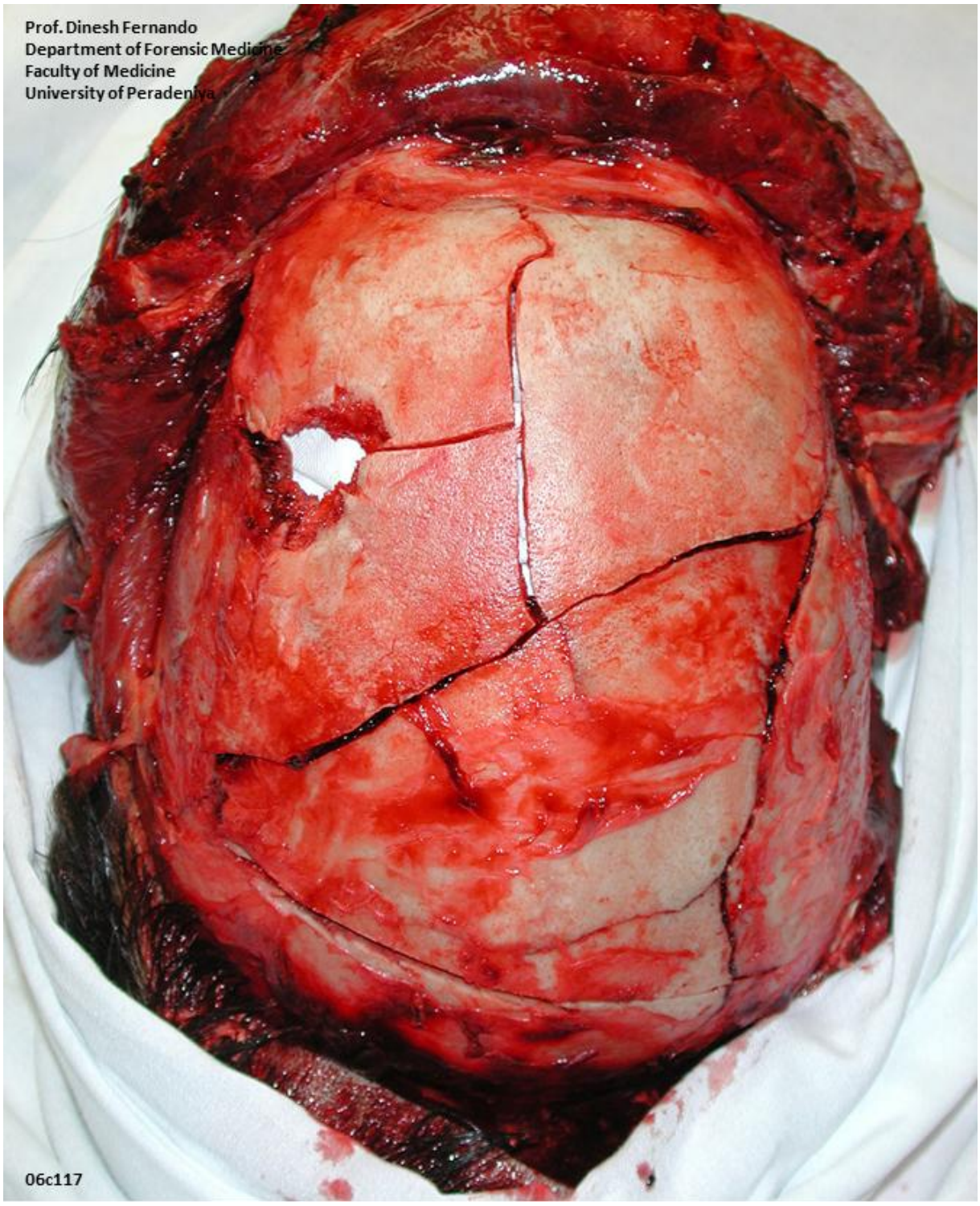


Figure 17: Circular bony defect measuring 10 mm in diameter on the left side of skull. Note circumferential bevelling on the outer table. A linear fracture extended superiorly to join the linear fracture extending parallel to the sagittal suture. Another linear fracture extended antero-inferiorly. Bilateral anterior cranial fossa fractures were present.

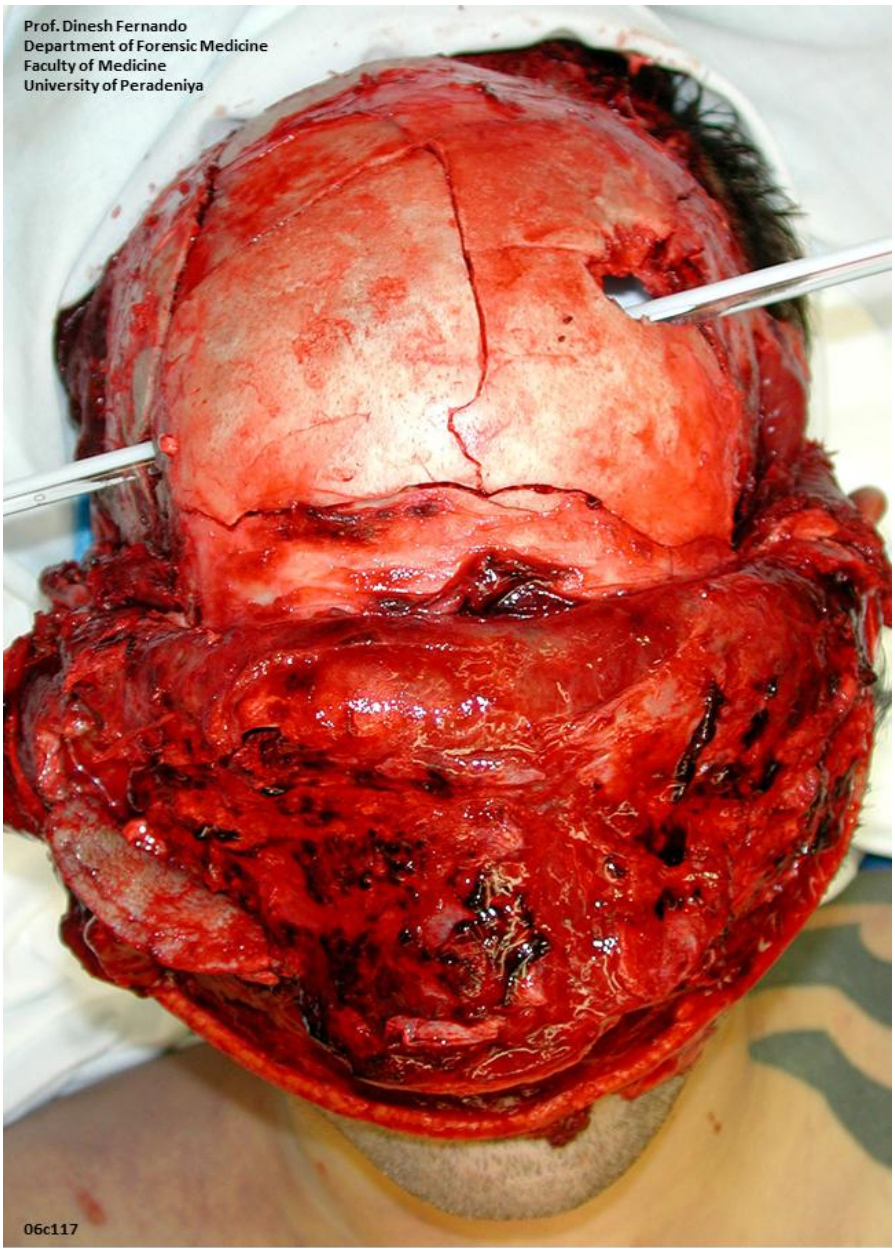


Figure 18: A probe passed through the right side skull defect extended upwards, slightly backwards and to the left, to exit from the defect on the left.

Cause of death and opinion

Head injury due to single discharge from rifled bore weapon to head. The entry wound was on the right temporal region of the skull with the missile travelling upwards, slightly backwards and to the left and exiting from the left parietal region of the skull. The range appears to be contact in view of the fact that there were stellate lacerations of the scalp, indicating gas trapping between the scalp and skull causing ballooning and laceration, multiple fractures of the vault and base of the skull and some soot adjacent to one part of the entrance on the skin.

History

A 33 year old male was shot by his brother with a hand gun loaded with a 7.65 mm rifle bullet which was recovered from a door in which it had lodged tail end first.

External examination

1. An oval shaped perforated laceration, 6 x 4 mm in size, was present on the left side of the chest just above the clavicle 70 mm from midline. There was no associated pinkish discolouration, burning or blackening around the laceration. Asymmetrical tattooing was seen around the wound, mainly on the superior aspect. An abrasion collar was present, more prominent on the upper left surface. The wound tract was directed downwards, to the right and posteriorly.
2. An irregular perforating laceration measuring 9 mm x 6 mm with everted margins situated on the right side back of chest. Contusion around the superolateral aspect was present. No abrasion collar, burning, blackening and tattooing noted.

Internal examination

Cardiovascular system

Tear in the lateral wall of left common carotid artery. Roots of three main branches of arch of aorta were intact. Jugular vein and heart was intact.

Respiratory system

The right thoracic cavity contained 750 ml of blood and the left contained 70 ml of blood. The right lung was collapsed and had a wound tract extending from apex to postero-lateral border of upper lobe. Patchy haemorrhage on surface of left lung was present.

Gastrointestinal tract

Upper end of oesophagus was perforated and the stomach contained 750 ml of blood. The small intestine also contained blood.

Musculoskeletal system

Perforation of the right scapula and grooving of superior margin of the 5^{th} rib.

Investigations

Skin around injury number 1 and 2 were analysed for gunshot residue.

Figure 19: Injury number 1.

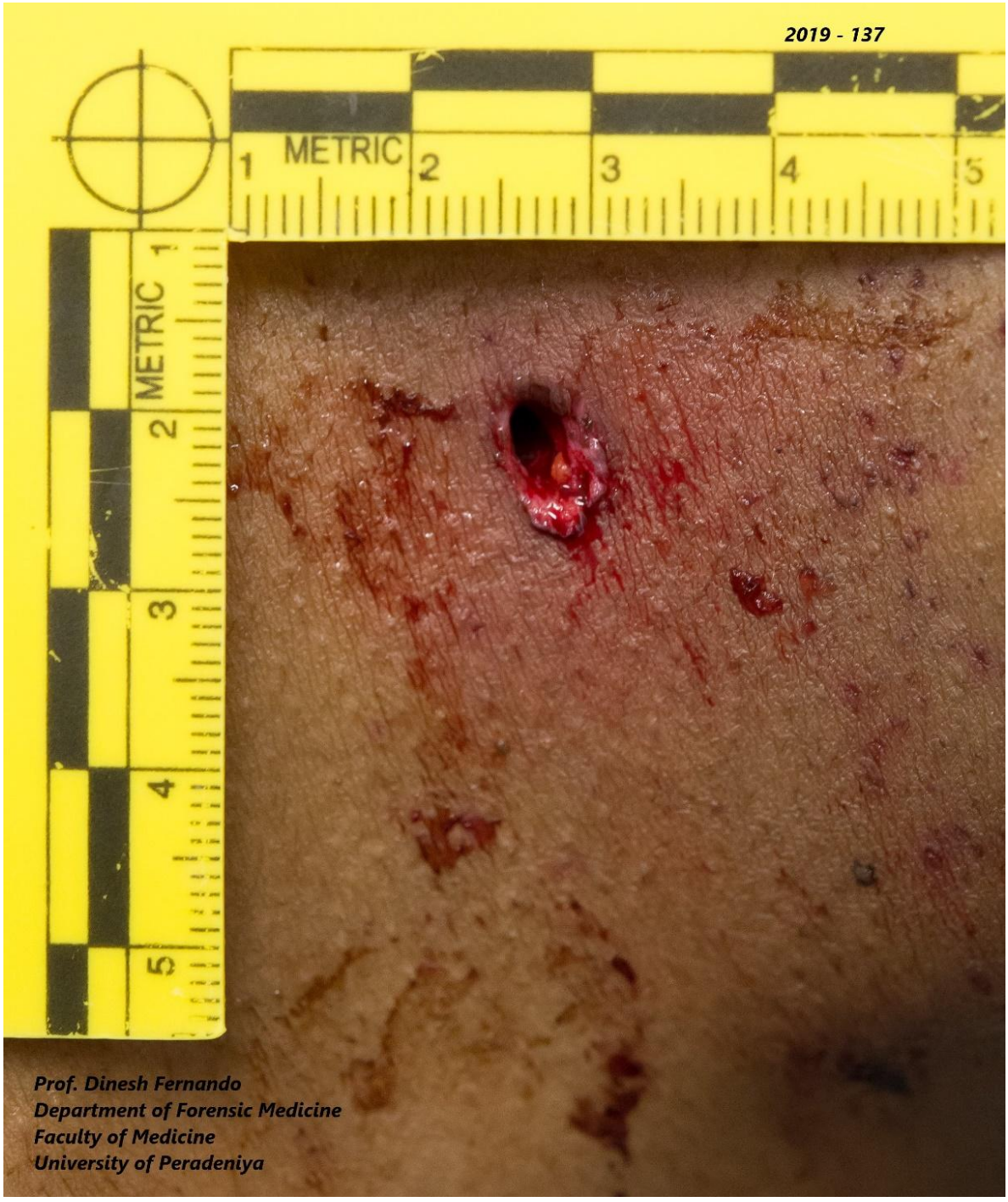


Figure 20: Injury number 1 close up view.

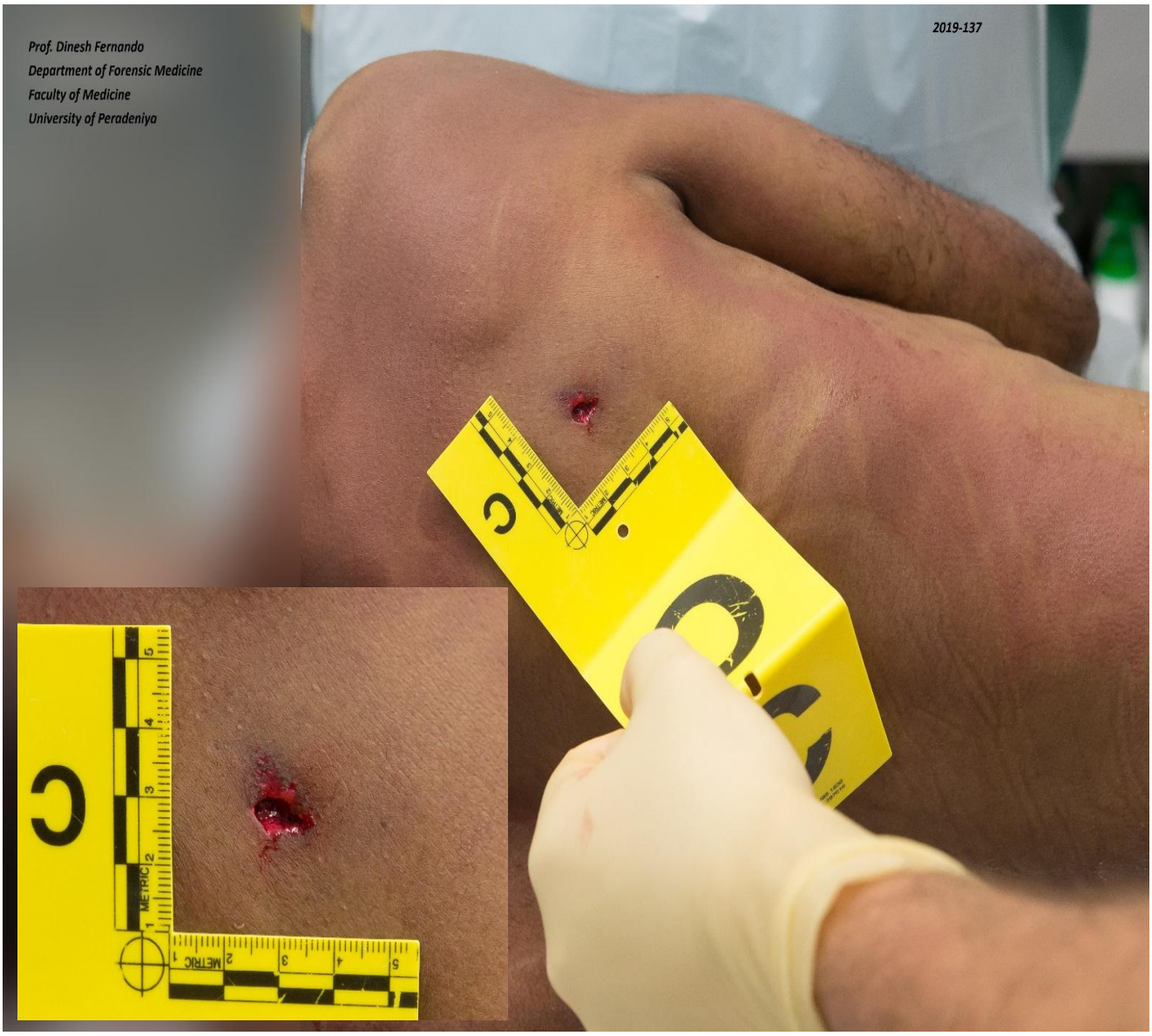


Figure 21: Injury number 2.

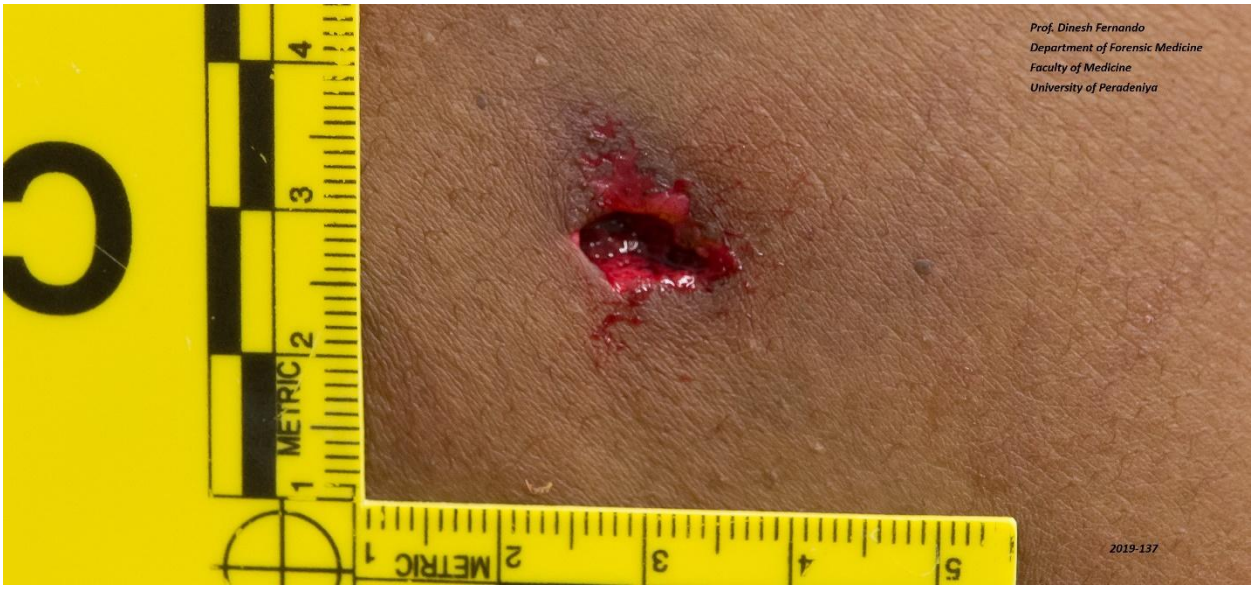


Figure 22: Injury 2 close up view.

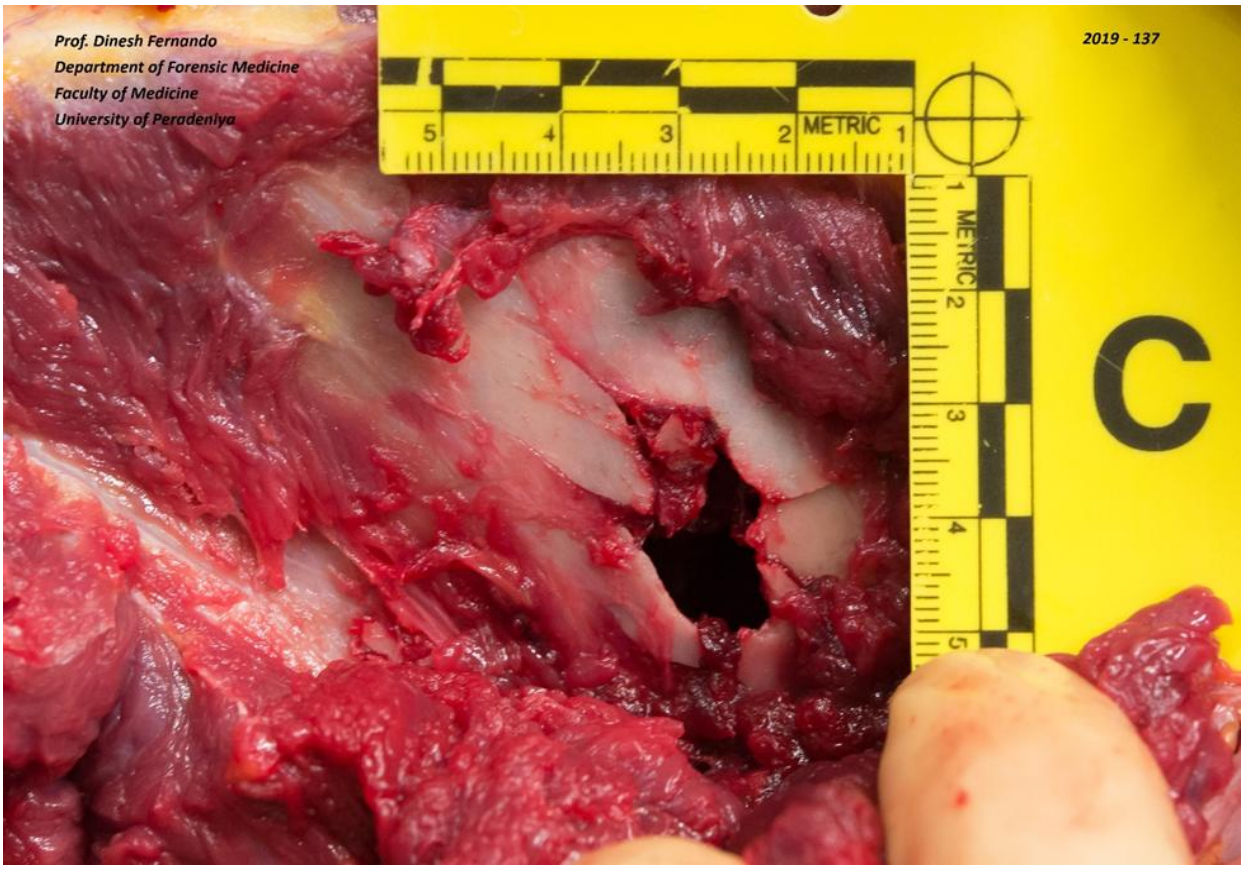


Figure 23: Irregular shaped deficiency measuring 21 mm x 10 mm on the right scapula associated with several radiating linear fractures.

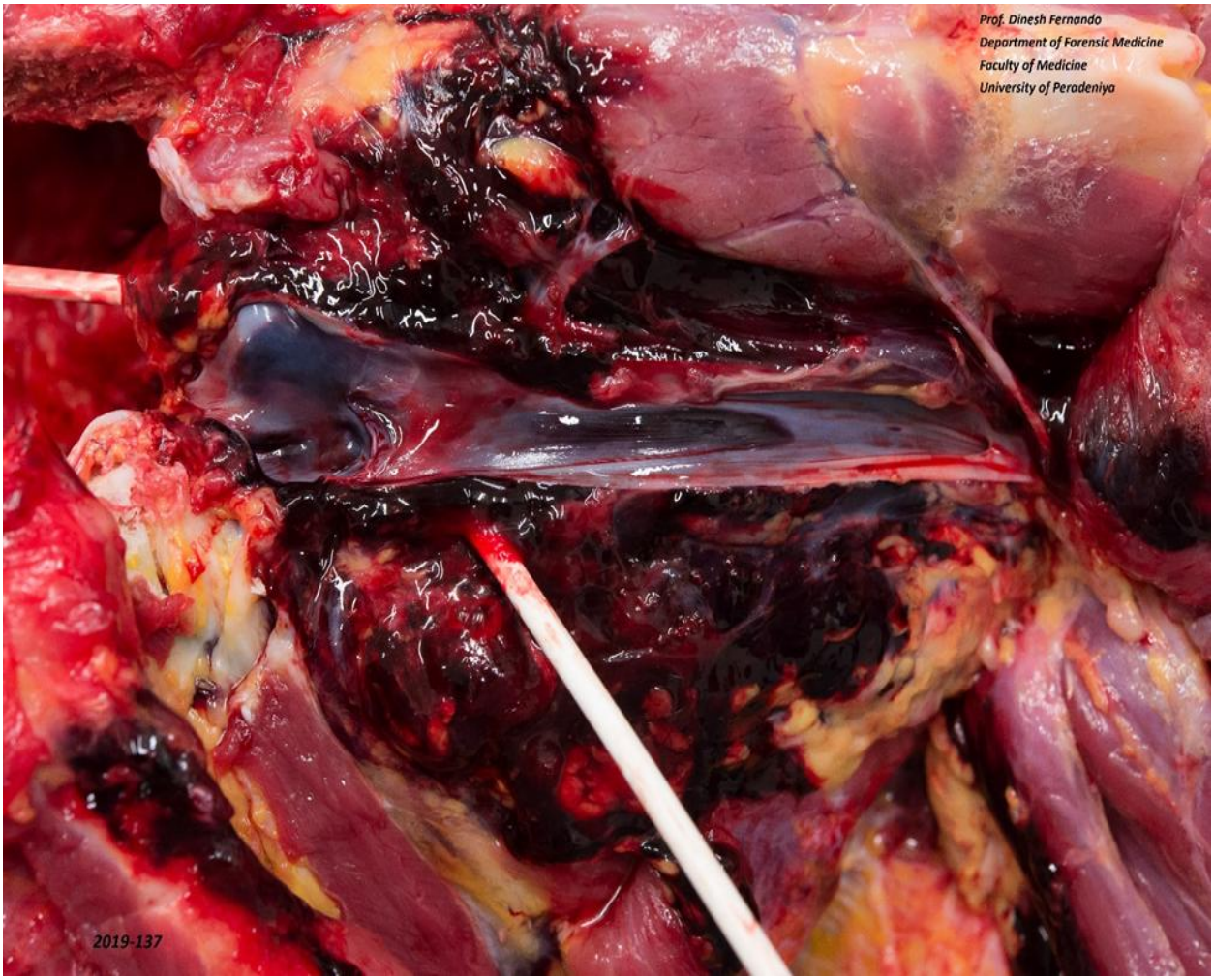


Figure 24: Opened jugular vein free of injury.

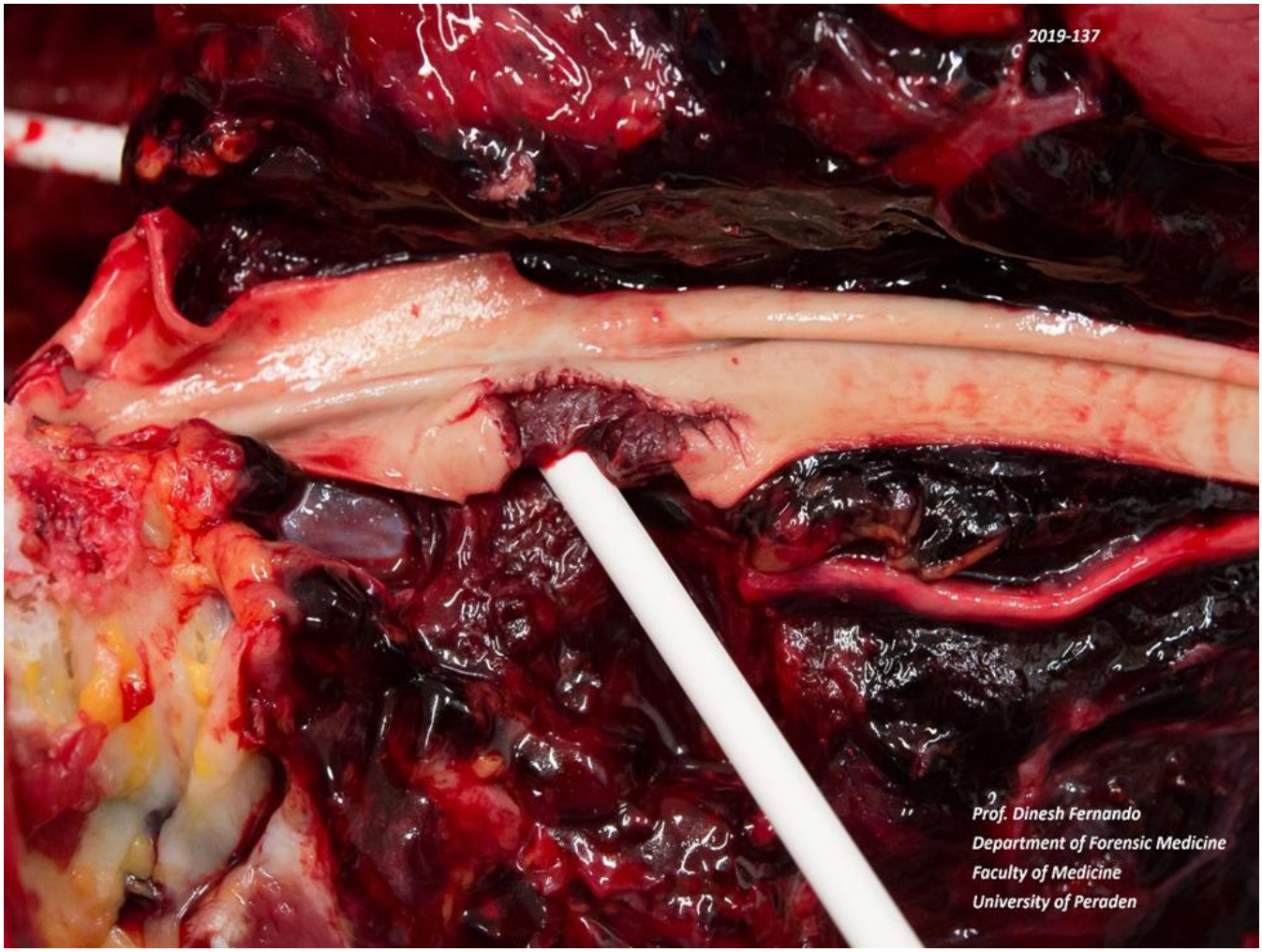


Figure 25: Opened left common carotid artery demonstrating the tear in the lateral wall. Note the haemorrhage around the tear.

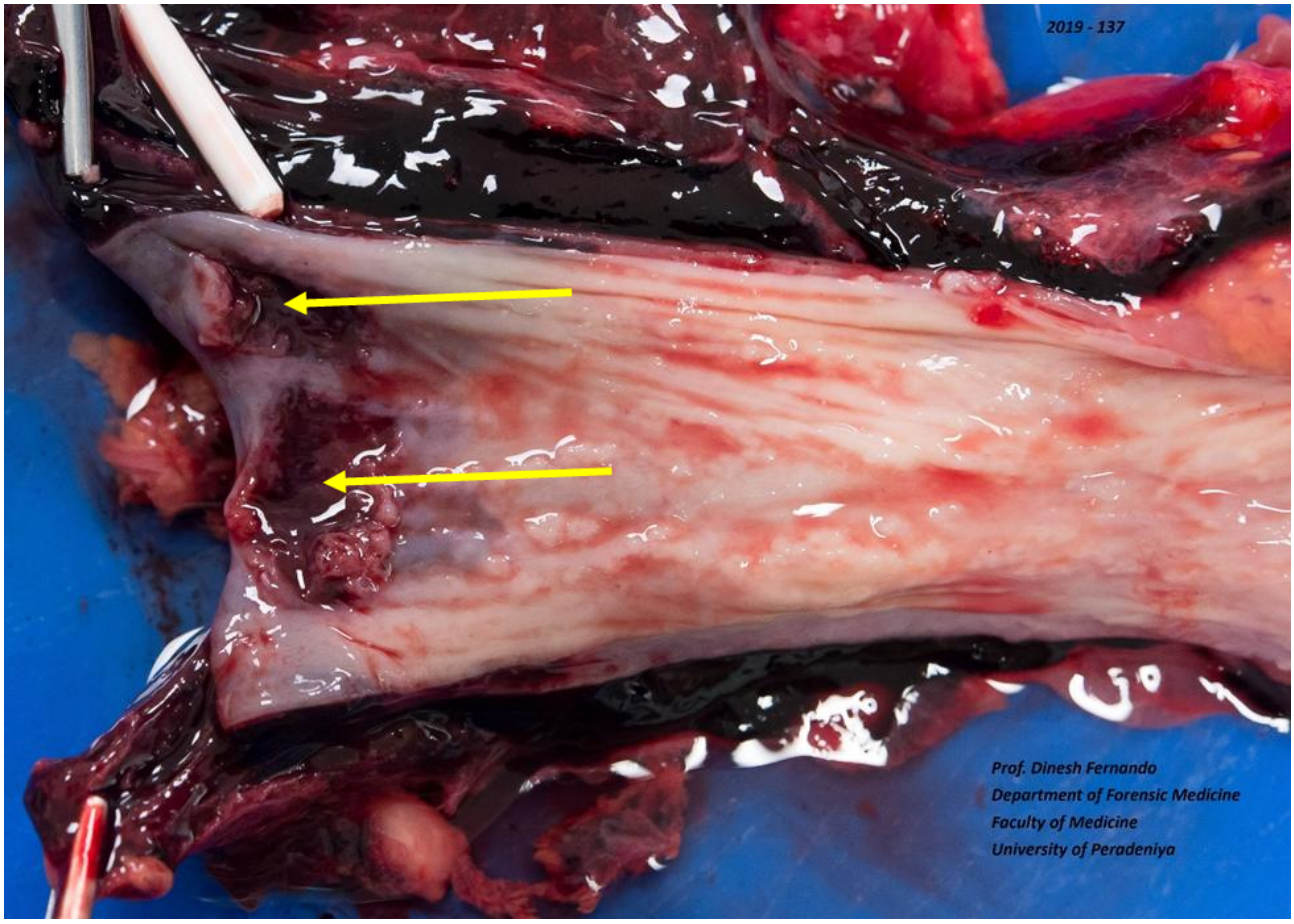


Figure 26: Oesophagus opened to demonstrate the through and through perforation. (Yellow arrows)

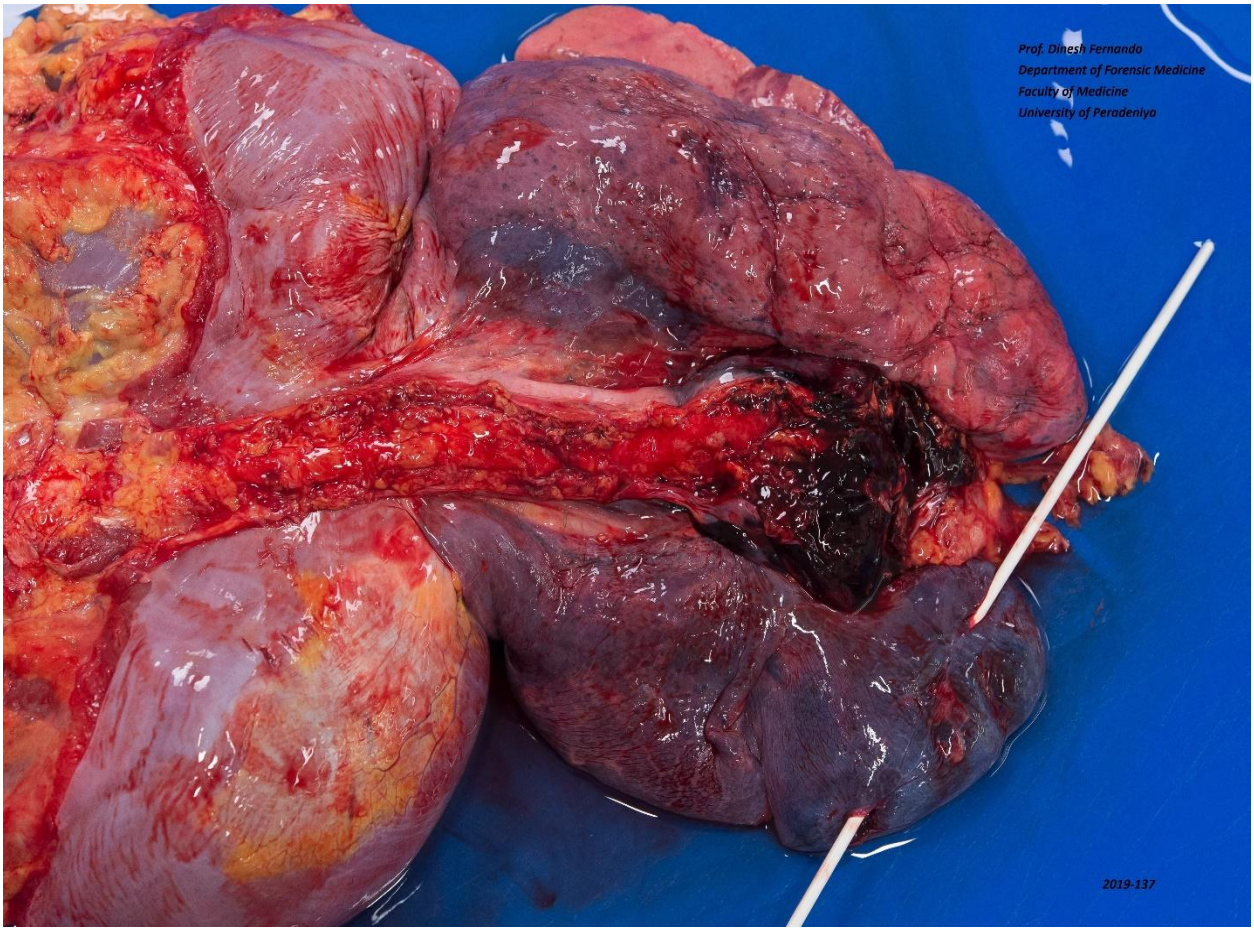


Figure 27: Tract through right lung from apex to the postero-lateral aspect of upper lobe

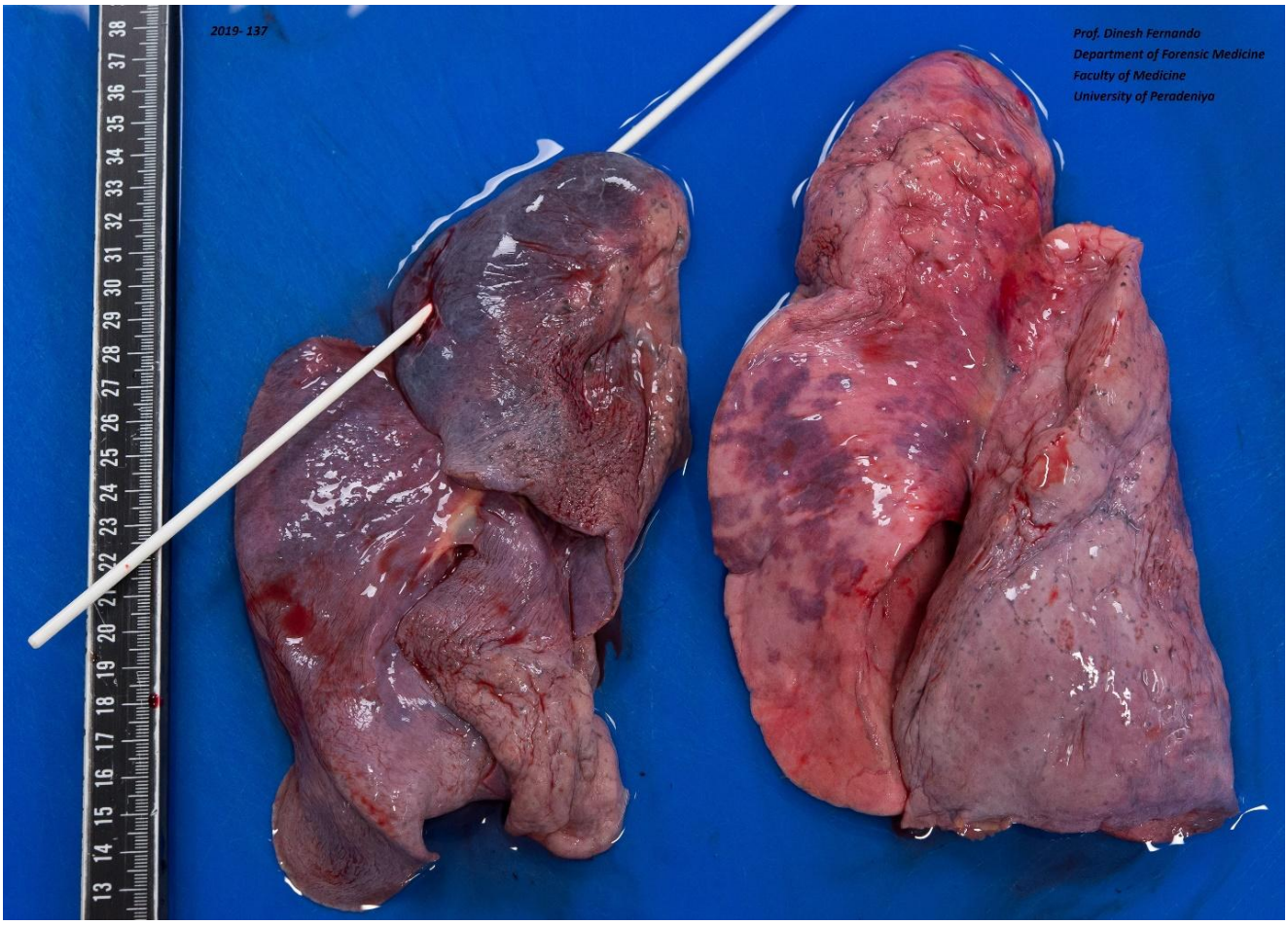


Figure 28: Collapsed right lung with tract of bullet demonstrated by a probe. Note the subpleural patchy haemorrhages on the left lung indicating aspiration of blood

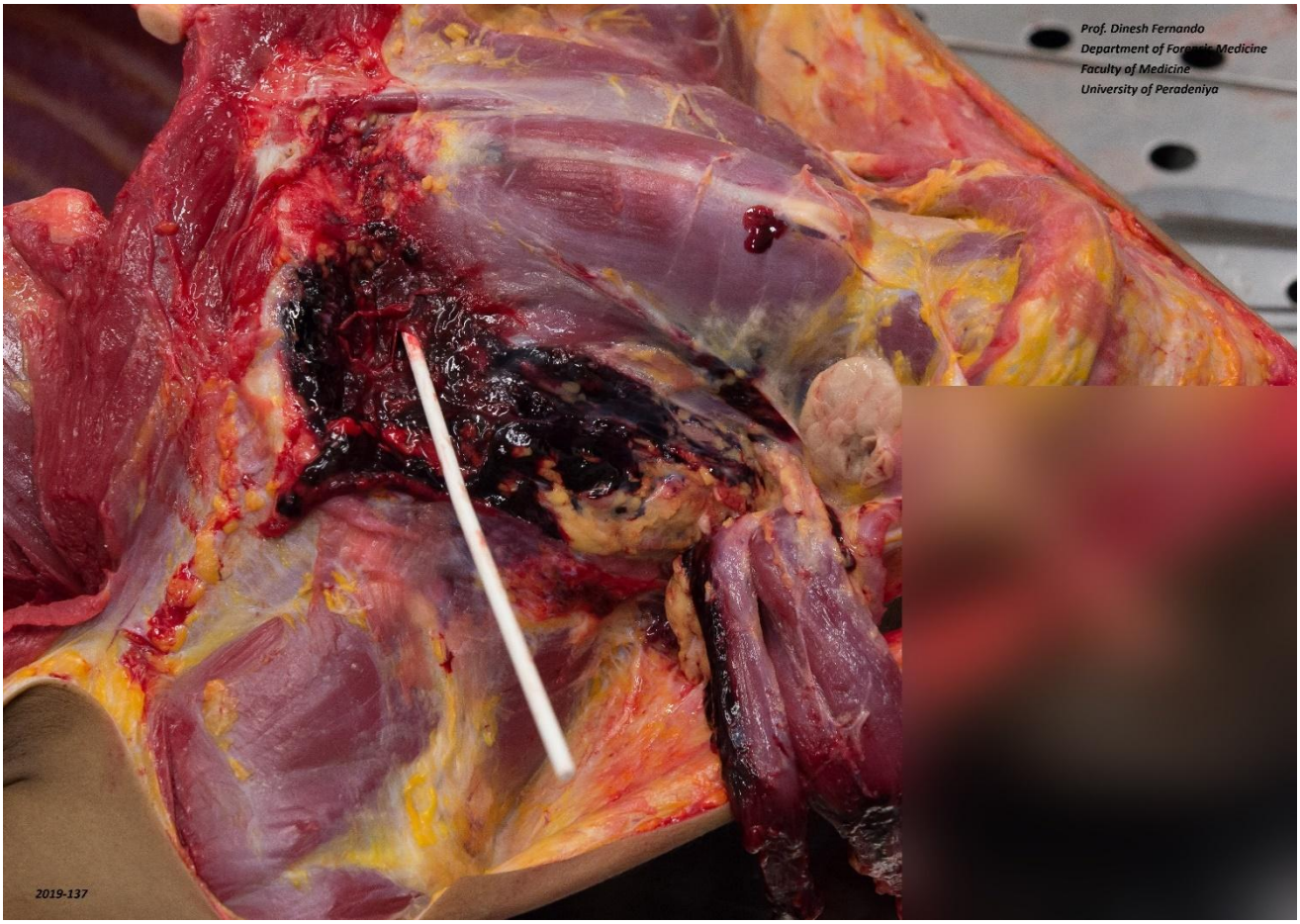


Figure 29: Layered dissection of the left side of neck showing haemorrhage around the perforation extending into the thoracic cavity (indicated by the probe).

Cause of death and opinion

Cause of death - Haemorrhagic shock due to tear of carotid artery caused by the missile of a rifled firearm.

Opinion – a rifled firearm entry situated on the upper left chest (root of the neck) directed downward, to the right and posteriorly. The absence of burning and blackening together with the presence of tattooing indicates a range of fire of 30 cm – 90 cm. (intermediate range, 1 – 3 feet). Asymmetric pattern of tattooing may be a result of clothing intervening on the lower part of the entry wound. The bullet which has entered the left side root of the neck causing a tear in the lateral wall of left common carotid artery, has perforated the upper end of the oesophagus and passed through the right lung, right scapula and exited from the back of chest causing a groove on the superior margin of the 5^{th} rib. Contusions around the exit indicates a shored exit (supported exit).

History

A 50 year old man fell down while jogging, bystanders say they heard a shot being fired but did not see the assailant. No cartridge case was found at the scene.

External examination

Petechial haemorrhages were seen in both conjunctivae (see page 4, chapter 1 on asphyxia volume 1, colour atlas of forensic traumatology)

An oval shaped perforating laceration, measuring 15 mm x 10 mm in size with a small laceration on posterolateral end was present on the right side temporal region directly above the ear. An eccentric abrasion collar more prominent on the antero-inferior aspect was present around the wound. There was no burning, blackening and tattooing.

Internal examination

A thick layer of haemorrhage was present on the inner aspect of the scalp surrounding the laceration. A 15 mm x 12 mm perforation of the underlying temporal bone, with no significant bevelling, was present. A subarachnoid haemorrhage was seen over the right hemisphere.

A deformed lead bullet with a few striations and a diameter of approximately 10 mm was lodged in the right posterior cranial fossa. A 20 mm x 10 mm segment of the occipital bone was fractured; however the bullet had not penetrated through the occipital bone.

The tract of the bullet was directed backwards, horizontally and slightly medially.

Investigations

Skin sample around injury was negative following gunshot residue (GSR) analysis.

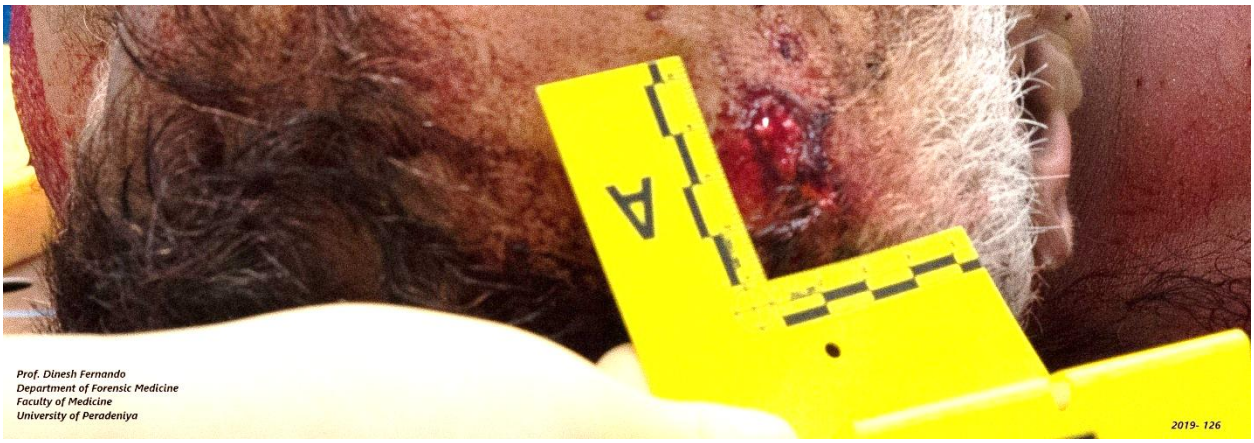


Figure 30: Perforating laceration above the right ear.

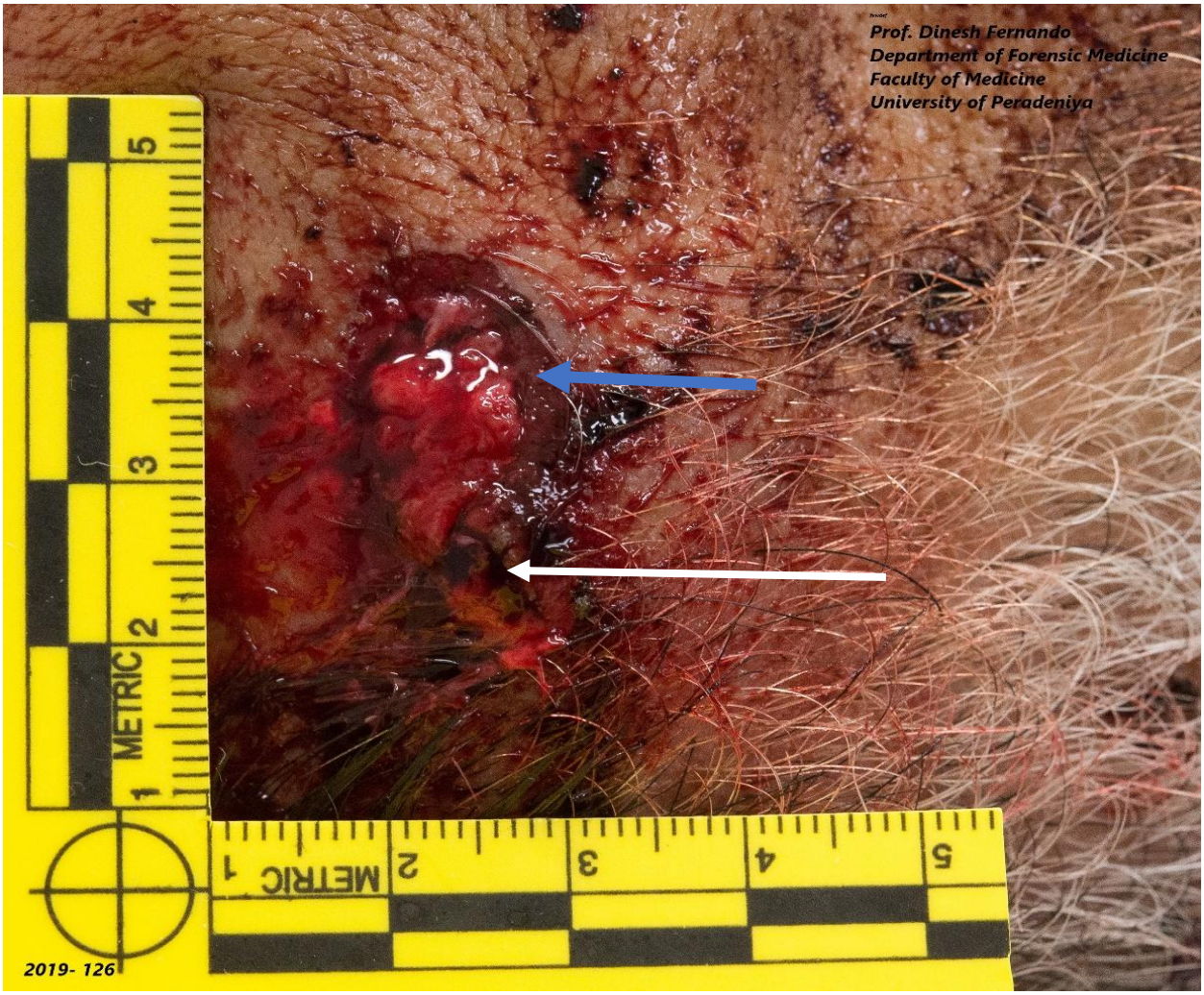


Figure 31: Close up of above injury. Note an eccentric abrasion collar (blue arrow) and a small laceration at the posterior end. (White arrow)

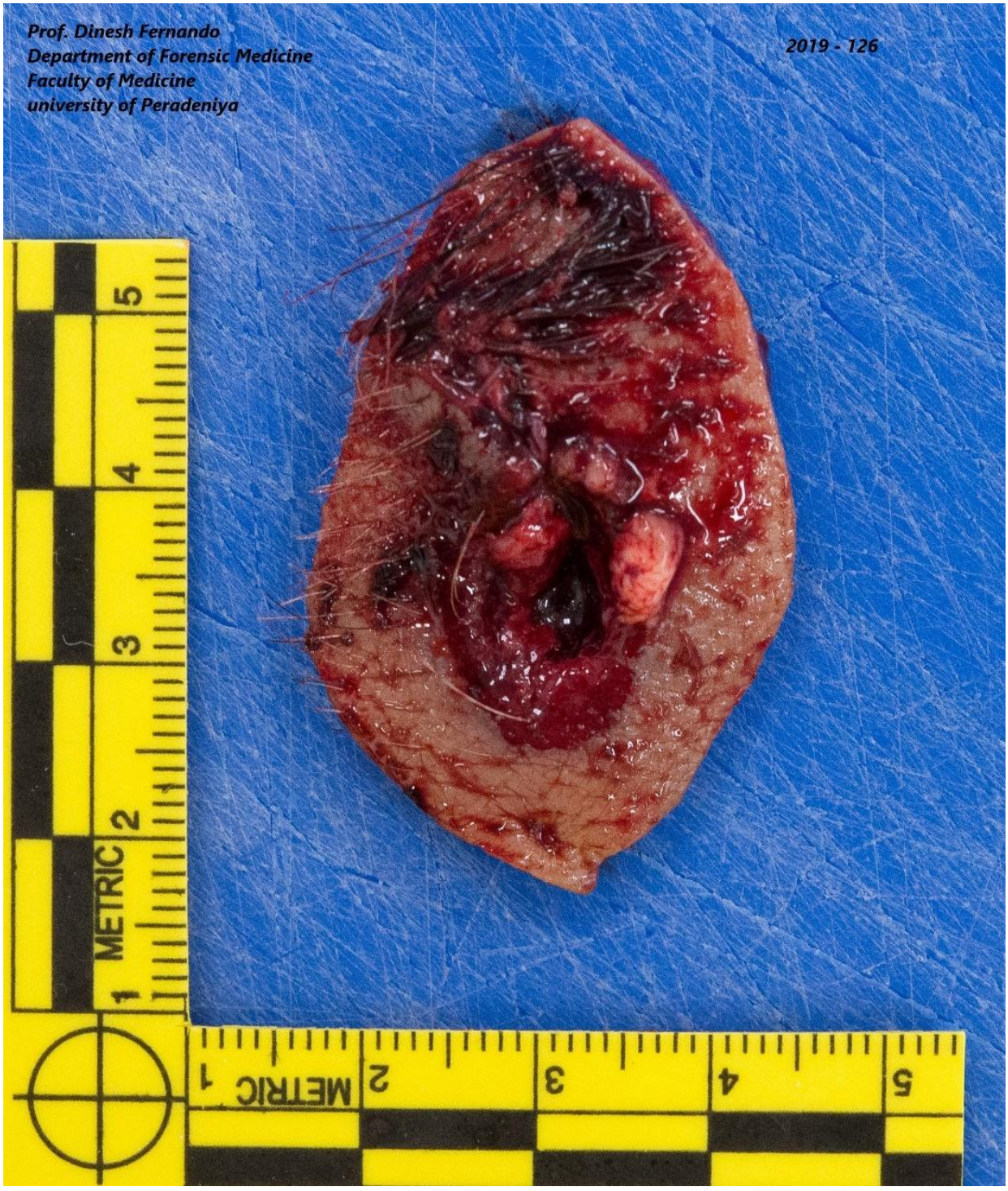


Figure 32: Removed piece of skin around the injury.

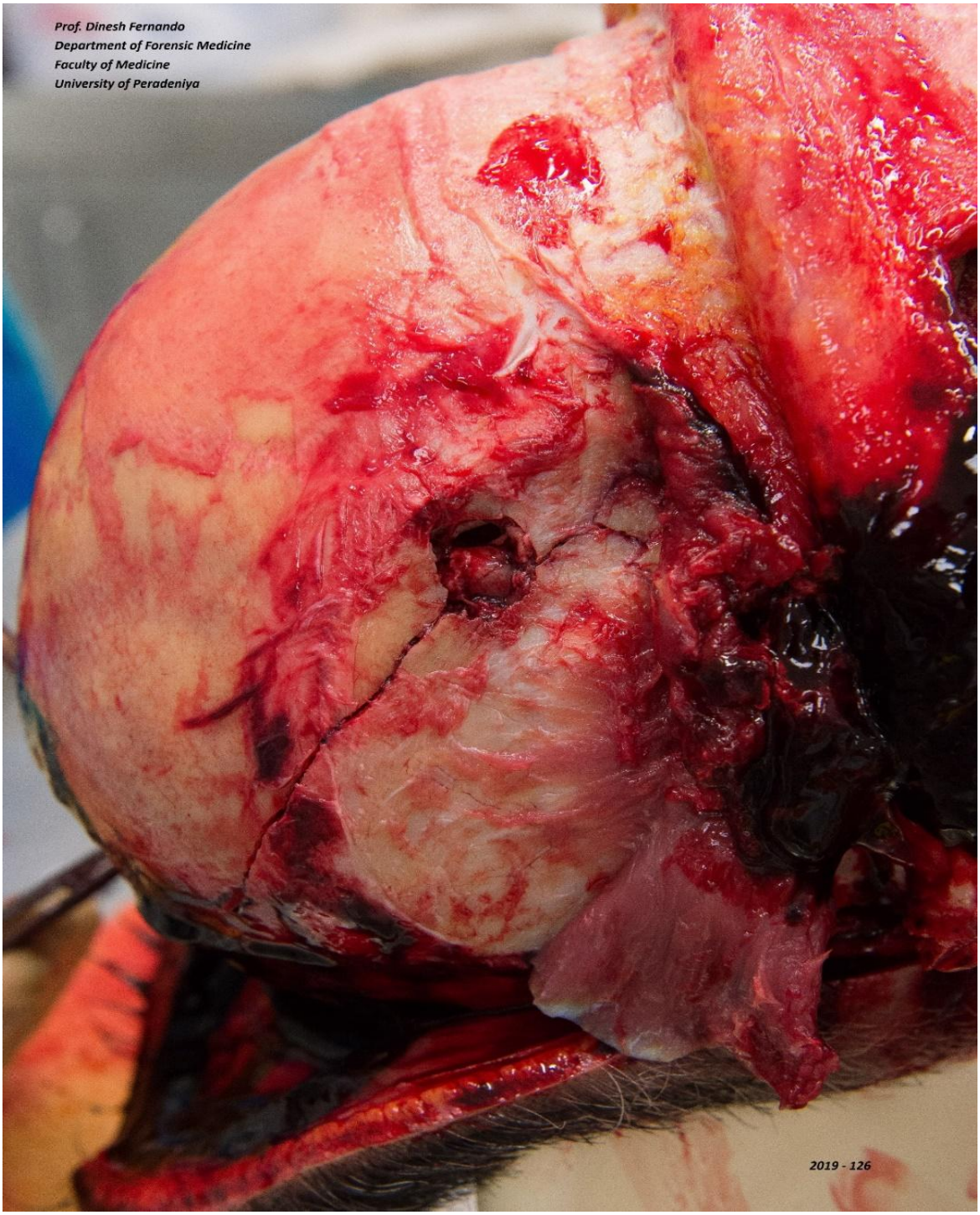


Figure 33: A 15 x 12 mm circular deficiency on the underlying skull related to the external injury. Note radiating linear fractures extending postero-superiorly and antero-inferiorly.

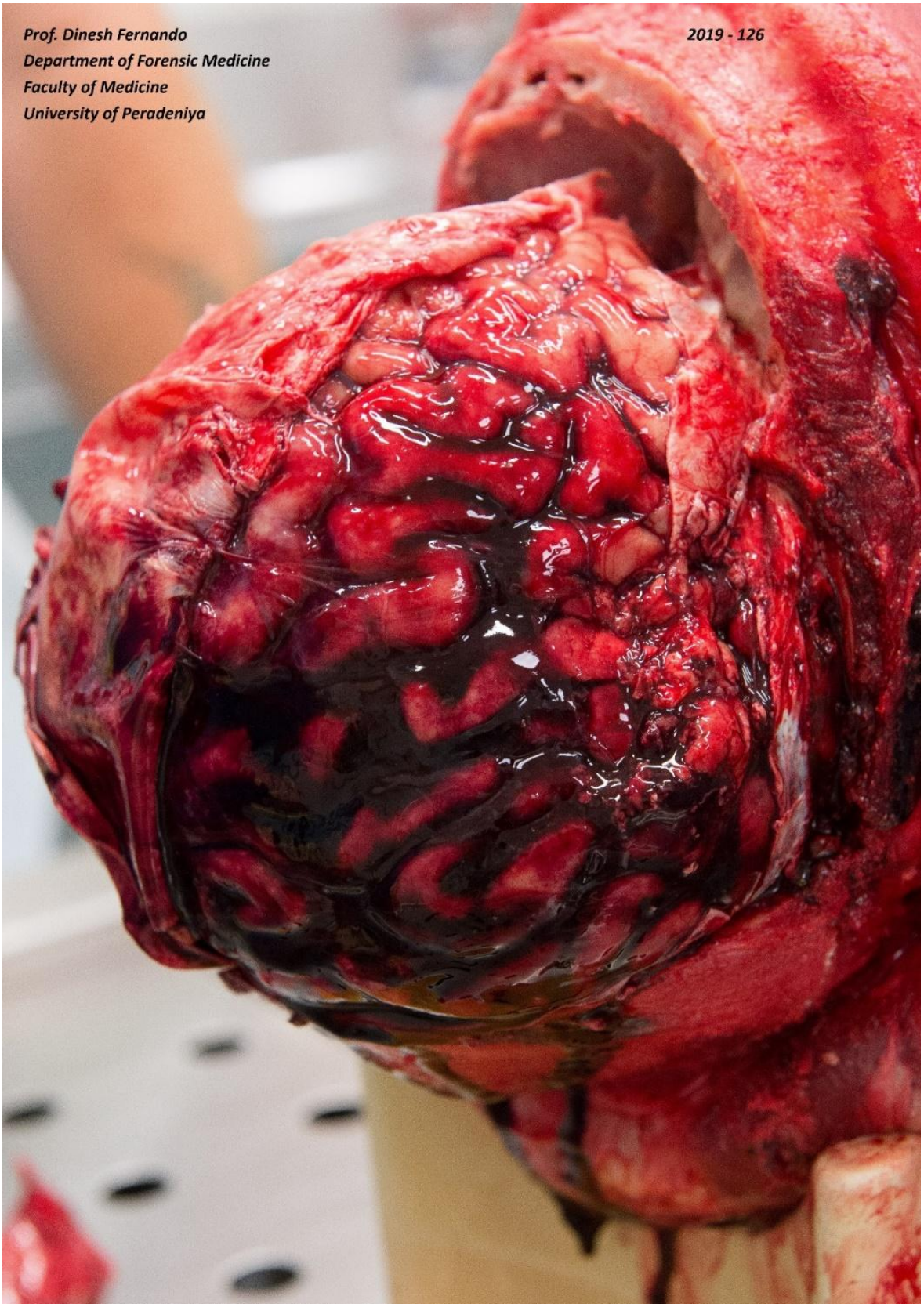


Figure34: Sub arachnoid haemorrhage.

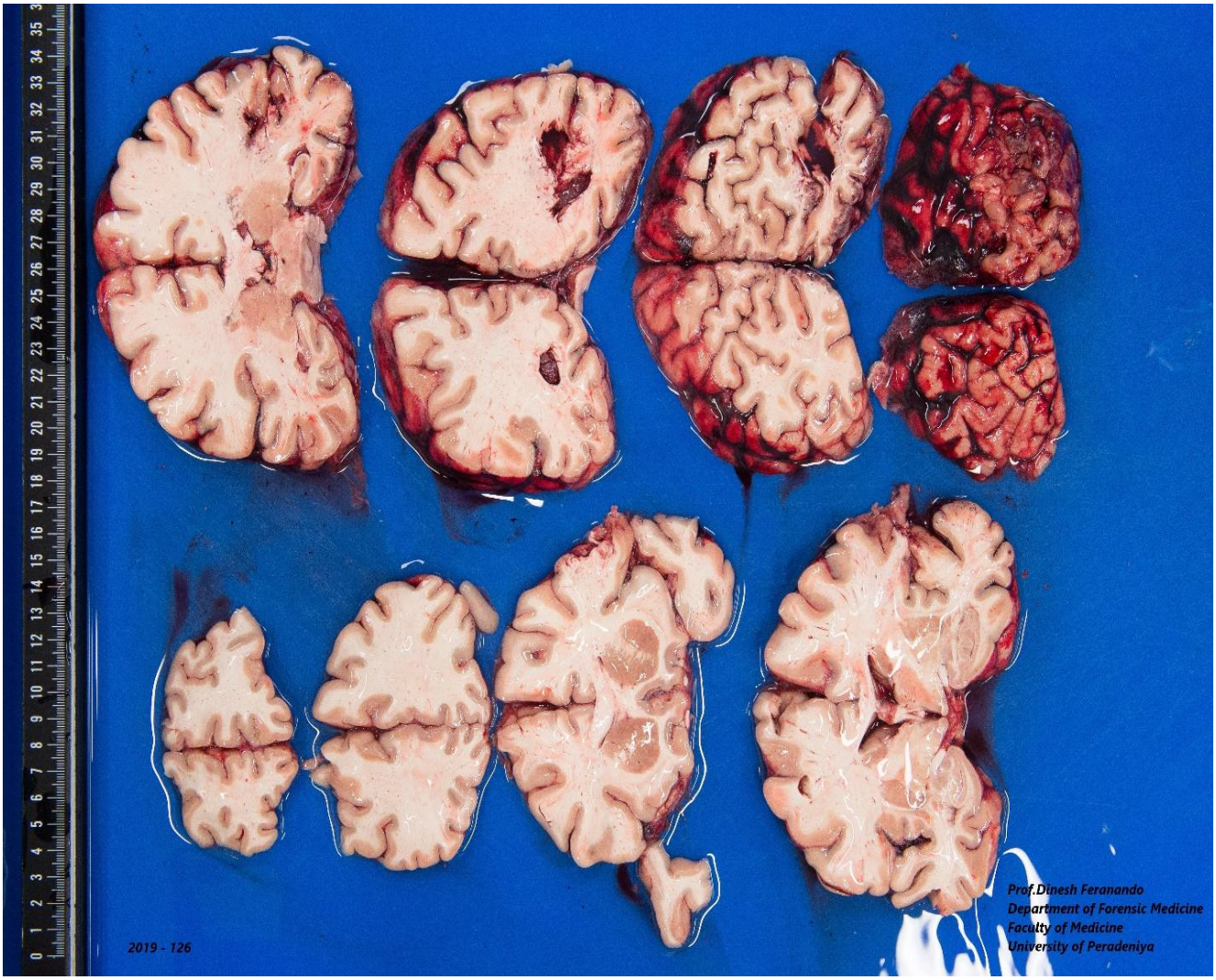


Figure 35: Coronal sections of the brain showing the tract of the bullet through the right temporal and parietal lobes. Note predominant sub arachnoid haemorrhage on the right side.

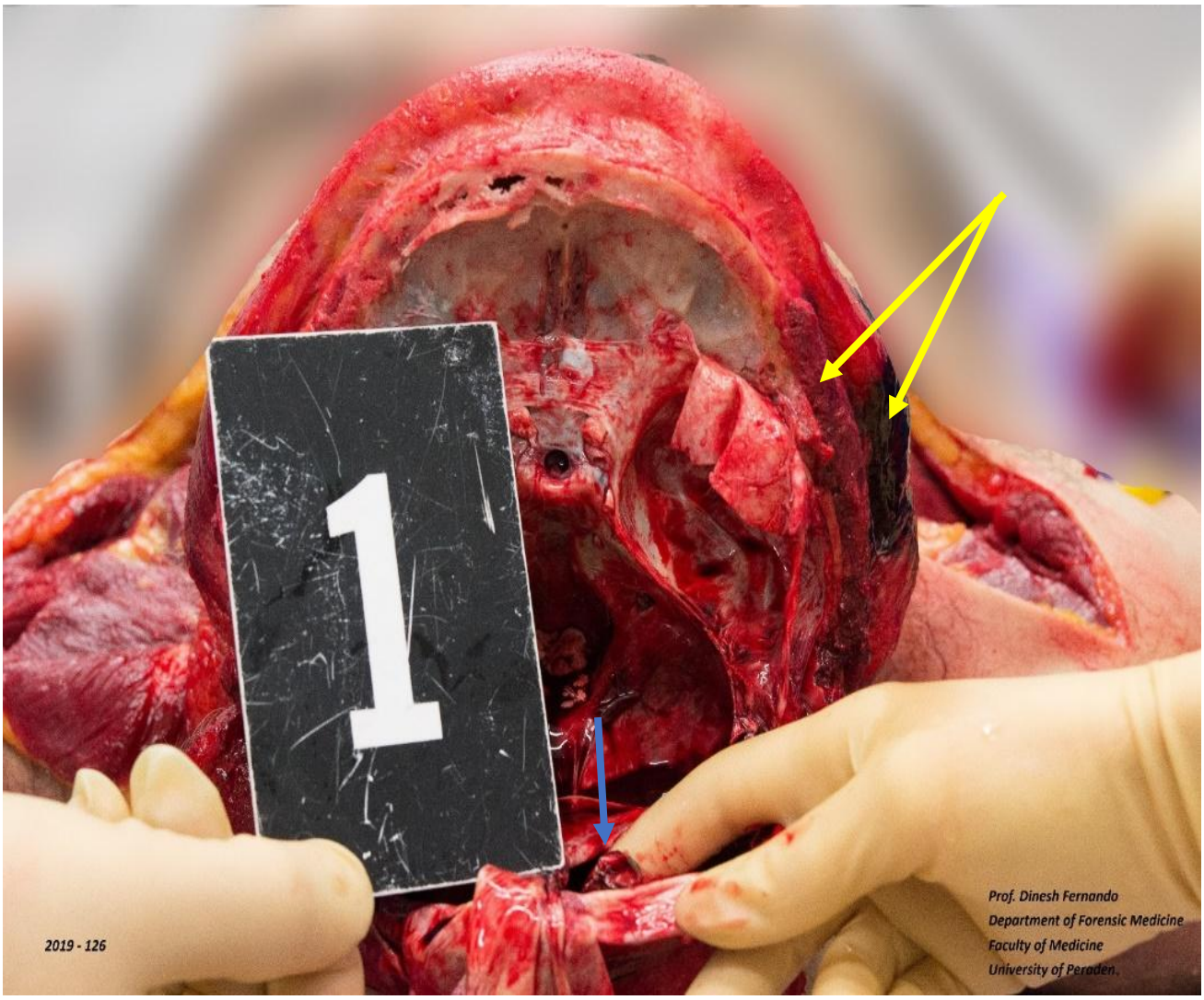


Figure 36: Missile in posterior cranial fossa. (Blue arrow) Note the haemorrhage in the temporalis muscle and adjacent scalp. (Yellow arrow)

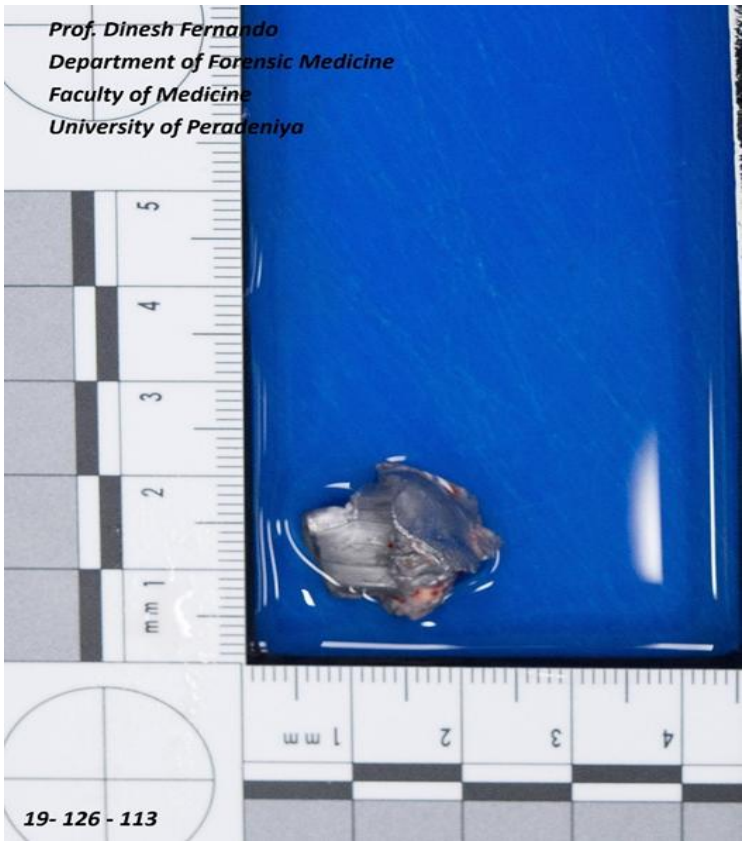


Figure 37: The deformed bullet recovered from the cranial cavity.

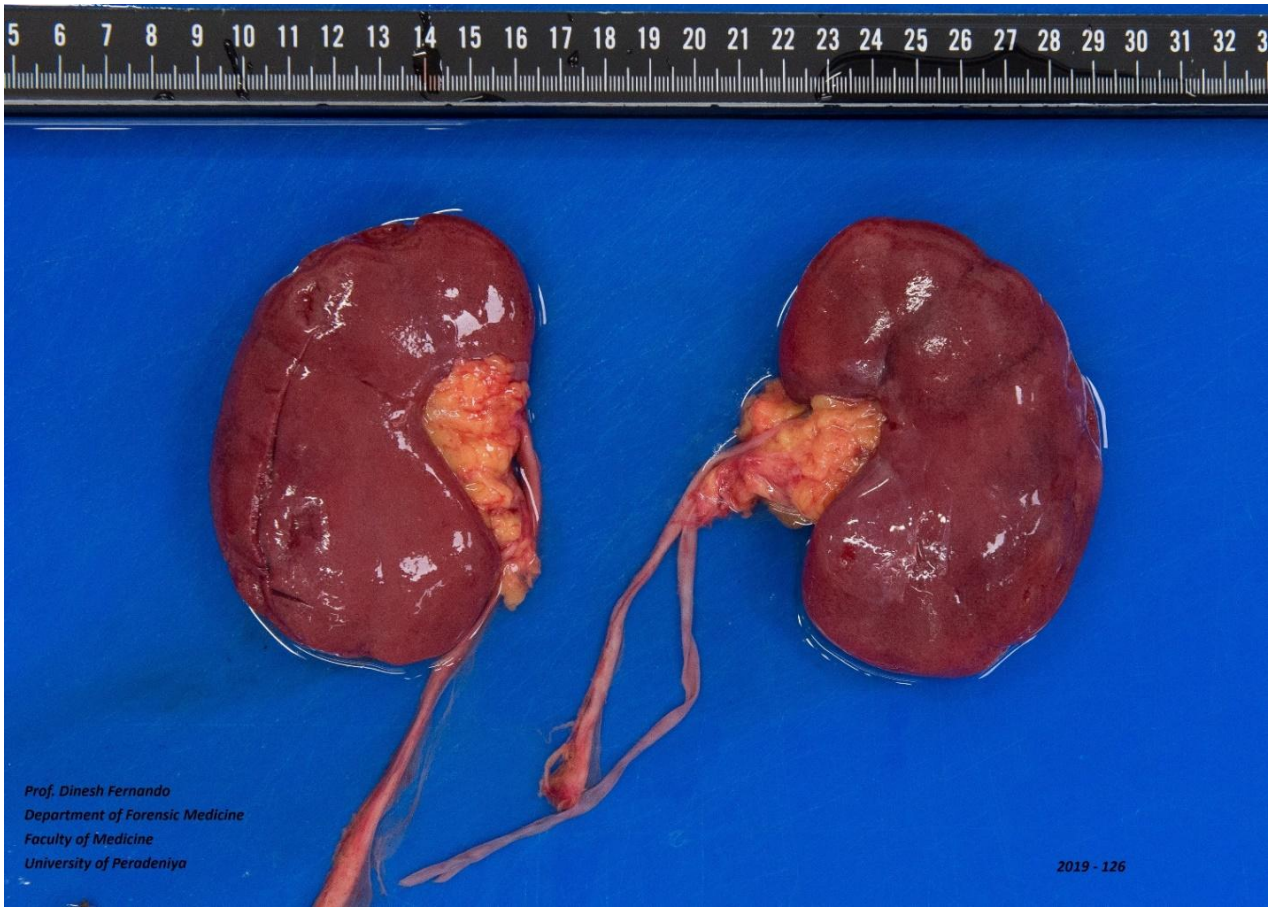


Figure 38: An incidental finding of a double ureter in one kidney.

Cause of death and opinion

Rifled firearm injury to the head from a distant range.

Bibliography

1. Saukko P, Knight B. Knight's forensic pathology. 4th ed. Boca Raton: CRC press; 2015
2. James JP, Jones R, Karch SB, Manlove J. *Simpson's Forensic Medicine*. 13th ed. London: Hodder Arnold;2011