

The BEST lines for skin surgery

A new paradigm

To minimise scarring, skin surgeons are guided by Langer lines and wrinkle lines, first identified over a century ago. Although based on limited data from cadavers, these historical studies have steered skin surgery for both incisions and excisions until recently. In a groundbreaking, first-of-its-kind study, Dr Sharad Paul at the Auckland University of Technology in New Zealand uses real-time skin tension data during excision surgery to map biodynamic excisional skin tension (BEST) lines throughout the body. With the resultant guide depicting these lines of least tension, Paul hopes to improve surgical outcomes and reduce scarring.

With an increasing prevalence of skin cancer worldwide coinciding with a demand for plastic surgery, the field of dermatosurgery (skin surgical procedures) is growing. Our skin has inherent tension because of underlying muscles, tissues, and joints. This tension inhibits wound healing, therefore surgeons try to cut along the lines of least tension to promote better wound healing and less scarring. Over 90% of patients surveyed want less scarring, so optimising surgical techniques to minimise the tension causing scarring is highly desired. To achieve this and promote optimal wound repair, cuts (incisions or excisions) should be made in the direction of least skin tension.

In a unique study providing real-time insight into skin tension during surgery in over 1,000 patients, Dr Sharad Paul at the Auckland University of Technology in New Zealand has revolutionised this subject, generating the first new theory in skin tension lines since the early work of 1861. Describing the biodynamic excisional skin tension (BEST) lines he has developed as 'a new paradigm', his recent findings present a new standard for skin lines, guiding practice worldwide.

INCISIONS AND EXCISIONS

Our skin is the body's first line of defence. This fascinating organ has an incredible ability to stretch and can even double in size. The dermis layer of the skin sits

underneath the top epidermal layer and consists of disorganised collagen fibres with less than 5% of the layer made up of elastin fibres. Skin surgery through this layer and often deeper layers involves two types of cuts: incisional and excisional. Incisions cut the skin open to gain access to an area, for example during joint replacement surgery, while excisions remove skin, for example to cut out skin cancer.

Excisions often scar more than incisional cuts, even if the latter are larger, presenting added complications. This is because the dermis layer undergoes mechanical loading or physical stress when skin is removed. An area known as an ellipse, shaped like a boat or eye, is marked for excision to remove skin defects such as cancer. The direction of this ellipse and where the excision is made can majorly affect scarring and appearance post procedure. A line of least tension should be followed during surgery to reduce this. In the field of dermatosurgery, these skin lines (the recommended lines to cut along during surgery) were determined historically and have been widely debated.

FROM PAST TO PRESENT

In 1861, Karl Langer, a pioneer in this field, studied skin lines in cadavers. He punctured their skin with a sharp object to make round holes and observed the elongation of these holes into an oval shape. This over 150-year-old study was only translated into English more than 100 years later and repeated in a small number of cadavers in 1941. This establishing work defined cleavage lines, also known as Langer lines, marking them the standard for surgical incisions with the least wound tension.

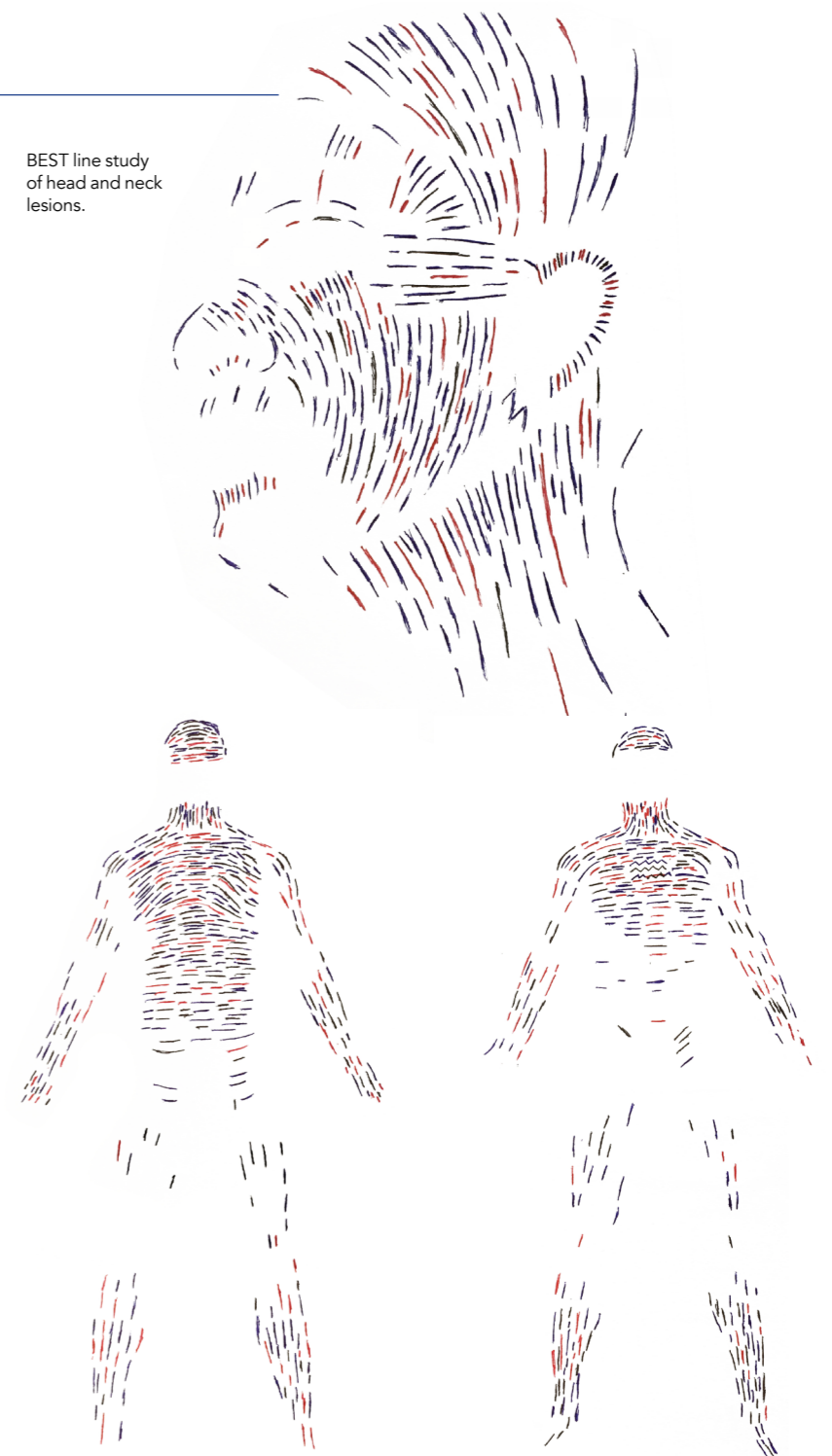
Although these pioneers believed that Langer lines varied with age and body shape, they have still been universally employed in dermatology.

Another pioneer, American plastic surgeon Alberto Borges, noticed that upon pinching skin, wrinkles are more pronounced when formed parallel to Langer lines. Named relaxed skin tension lines (RSTL), he proposed these be used for facial excisions. The third historical approach by Kraissl and Rubin involved visualising wrinkle lines. Kraissl took photographs of people purposely contracting their facial muscles to determine the location of wrinkle lines, whereas Rubin recorded wrinkle lines by impressing these on paper. Even experiments in the 1960s and 1970s used the same methods. Until now, these historical studies and a small number of clinical studies alone have informed the discipline of cutaneous (skin) surgery.

With significant advances in surgery and technology over the last century, new research was needed to better understand skin tension and more scientifically pinpoint the lines of least skin tension. The historical research hasn't taken into account the biomechanical difference between incisions and excisions, a significant factor that can no longer be ignored. Furthermore, the data is mostly from cadavers and not living patients, so muscle contraction had not been considered.

Now, in the largest study of its kind with 1,181 patients, measurements of skin tension in real time before and during surgery has enabled the mapping of biodynamic excisional skin tension lines (BEST) across the body. This extensive study covered a wide age range, from 13–95 years old, and the majority of patients were undergoing the procedure for skin cancer removal. Paul first made a circular excision using a computerised tensiometer to measure skin tension in real time. Then, he converted that incision to what is known as an elliptical excision based on the orientation associated with the wound healing under the least tension. This excision line, known as a BEST line, is the line of least tension. These were mapped throughout the body, providing a comprehensive guide for skin lesion excisions.

BEST line study of head and neck lesions.



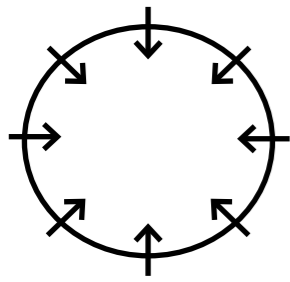
Biodynamic excisional skin tension lines mapped in the posterior (left) and anterior (right) view.

Measurements of skin tension in real time has enabled the mapping of biodynamic excisional skin tension lines (BEST) across the body.

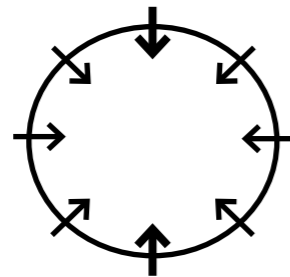
THE BEST LINES FOR SURGICAL EXCISIONS

The skin on our face has unique features, differing from the rest of the body because of its superficial musculo-aponeurotic system (SMAS) – a network

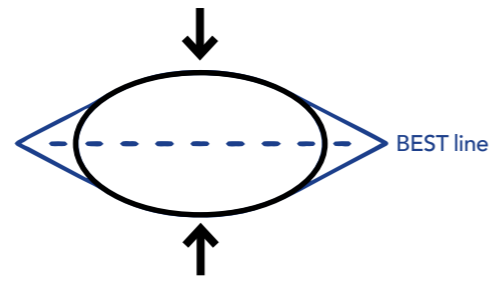
of facial muscles and connective tissue. As a result, the BEST lines for facial surgery are remarkably like the RSTL, with some differences in areas where BEST lines should be used preferentially to minimise scarring. BEST lines were also



Circular excision of skin lesion and tensiometer measurements.



Line of least wound-closure tension determined.



Defect converted to eclipse. Surgical excision is done along the BEST line.

Methodology of the biodynamic excisional skin tension (BEST) line study.

mapped for the scalp, trunk, and limbs, with their direction differing depending on the location.

Furthermore, Paul's study exposed differences between the direction of BEST lines and those historically established. For example, on the scalp, Langer lines run in a sagittal direction (dividing the body into a left and a right section), while BEST lines run in a coronal direction (dividing the body into a front and back section). Paul demonstrated in his study that BEST lines

reveals that 1mm beneath each newly developing wrinkle lies a new lymphatic vessel, so using wrinkle lines on the limbs may have unforeseen consequences for cancer surgery due to the increased wound closure tension. BEST lines on the limbs tend to run vertically ie, aligned with the direction of the long bones.

Another insight from the study was the finding of significant pre-tension in the front and back of the body defined in part by body weight and joint movement,

other hand, during excisions that create larger wounds, collagen stretches and elastin buckles. This study emphasised the difference between incisions and excisions and that historical Langer and RSTL are not the most appropriate option for excisions. Another key finding is that skin tension and BEST lines are highly consistent between people and vary minimally with age and sex, making their use in different individuals standardised.

A NEW PARADIGM

In a quest to improve surgical outcomes and cosmetics, Paul's research challenges historic standards and completely reassesses the concept of skin lines. His groundbreaking study not only identifies BEST lines, the most suitable for excisions, but also reveals that these differ from the lines currently shown in textbooks and widely employed in the surgical world. This may be due in part to the profound differences between incisions and excisions. Paul proposes that Langer lines and wrinkle lines are more appropriate for incisions, not excisions – certainly not for excisions greater than 8mm. He advises surgeons to follow BEST lines during surgical excisions to achieve the best healing and least scarring; his results are now embedded in textbooks to guide surgeons.

Paul acknowledges the historical pioneering work in this field but highlights the advantage of using innovative technology to accurately measure skin tension in living patients. The in vivo nature of the study is not the only unique feature; it is also the largest skin line study in humans and made the first real-time measurements during skin surgery. Paul hopes this new paradigm will be implemented into clinical practice for the benefit of patients worldwide.

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have less tension than those in the sagittal and oblique (slanting) directions.

This study also confirmed that excisions in the lower limb using BEST lines result in less wound closure tension compared to RSTL/wrinkle lines. Paul therefore suggests wrinkle lines are not suitable for excisions – especially skin cancer excisions – and BEST lines should be used for optimal surgical outcomes and reduced scarring. Also, Paul notes recent research

especially shoulder and scapular (shoulder blade) movements. Furthermore, Paul showed this pre-tension can lead to incorrect RSTL when using the pinch method, with knock-on effects for wound healing under greater tension.

Differences between incisions and excisions are evident in microscopy studies of elastin and collagen. During incisions under minimal tension, elastin stretches and collagen buckles. On the



Paul is measuring tension along different directions using a specially designed tensiometer.



Behind the Research

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Research Objectives

Dr Sharad Paul identified biodynamic excisional skin tension (BEST) lines that may improve surgical outcomes and reduce scarring.

Detail

Bio

Dr Sharad Paul is Director of the Skin Surgery Clinic, Adjunct Professor at Auckland University of Technology, and Fellow of the Skin Cancer College of Australasia. In 2015, Paul received the Ko Awatea International Excellence Award for Leading (Health) Improvement on a Global Scale for 'improving skin cancer management, education and patient-centred care across several countries'.

Collaborators

- Professor Cliff Rosendahl (University of Queensland) and Professor John Windsor (University of Auckland) supervised the research associated with the 'BEST lines for cutaneous surgery' project on behalf of the University of Queensland.
- The Design and Creative Technologies Department of the Auckland University of Technology helped develop the devices used in this study.



The cover of the Royal College of Surgeons, Volume 100 No 4, includes Paul's signed illustration.

References

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Personal Response

What inspired you to conduct this research?

It was an observation during my surgical training that incisional wounds such as orthopaedic joint replacement surgery wounds rarely developed problematic scars whereas smaller, meticulously closed wounds after skin cancer excisions often did, even in experienced plastic surgical hands. I asked myself: Are skin lines for surgical egress (low load) biomechanically different from lines for surgical excisions (high load)? How did a few cadaver studies end up the benchmark for skin lines?

Are there any things that have surprised you during this project?

Wrinkles determine more than skin tension. Skin patterns also determine underlying health. I like saying, 'One cannot have bad health and good skin'. Wrinkles in certain locations can indicate a risk of heart disease. Also, there is a link between biomechanics and behaviour ie, abnormal brain development of the foetus in the womb may manifest in skin tension lines variations on the scalp that mean there is a link between scalp whorl patterns and mental health, for example.

