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Innovations in Needle Coatings: Reducing Tissue Trauma and Improving Accuracy in Medical Procedures

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INTRODUCTION & AIM

Background: Needle penetration is crucial in various fields, especially in medical applications. Recent studies indicate that, in addition to size and point type, needle coatings significantly impact penetration forces. During needle insertion, the needle body directly contacts biological soft tissue, often leading to tissue adhesion and varying degrees of tissue damage. Therefore, coating needles can substantially reduce tissue trauma during insertion.

METHOD

Methods: Optimizing the needle surface, particularly through coatings, can effectively address these issues. Various coatings, including biocompatible hydrophilic, metallic glass, silicone, and composite materials, have been studied. These coatings can reduce friction during insertion, minimize tissue adhesion, and decrease insertion and extraction forces.

RESULTS & DISCUSSION

Results: Coating surgical needles with a composite material (Polytetrafluoroethylene, Polydopamine, and Activated Carbon) reduced insertion and extraction forces, showing promising results with a reduction in insertion force by up to 49% and tissue damage by 39% in bovine kidney experiments. This coating also minimized tissue damage during percutaneous procedures. A biocompatible hydrophilic coating on a needle reduced tissue damage and adhesion during a puncture biopsy procedure. A silicone coating enhanced the durability and sharpness of surgical needles when passing through certain tissues, and a metallic glass coating on tattoo needles reduced skin trauma and improved tattoo quality.

CONCLUSION

Conclusions: These innovations in needle coatings show promise for minimizing tissue damage, improving precision, and promoting faster healing.

FUTURE WORK / REFERENCES

1. Carvalho M, Rocha AM, Carvalho H: **Comparative study of needle penetration forces in sewing hems on toweling terry fabrics: influence of needle type and size**. *Autex Research Journal* 2020, **20**(2):194-202.
2. Patel KI, Zhu L, Ren F, Hutapea P: **Effect of composite coating on insertion mechanics of needle structure in soft materials**. *Medical Engineering & Physics* 2021, **95**:104-110.
3. Ullah A, Kim CM, Kim GM: **Porous polymer coatings on metal microneedles for enhanced drug delivery**. *Royal society open science* 2018, **5**(4):171609.
4. Cárcamo-Martínez Á, Anjani QK, Permana AD, Cordeiro AS, Larrañeta E, Donnelly RF: **Coated polymeric needles for rapid and deep intradermal delivery**. *International Journal of Pharmaceutics: X* 2020, **2**:100048.
5. Patel K, Hutapea P: **Study of Tissue Damage Induced by Insertion of Composite-Coated Needle**. *Medical Engineering & Physics* 2024, **123**:104094.