Assessment of injection and penetration depth of a novel intradermal drug delivery device

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1. INTRODUCTION & AIMS

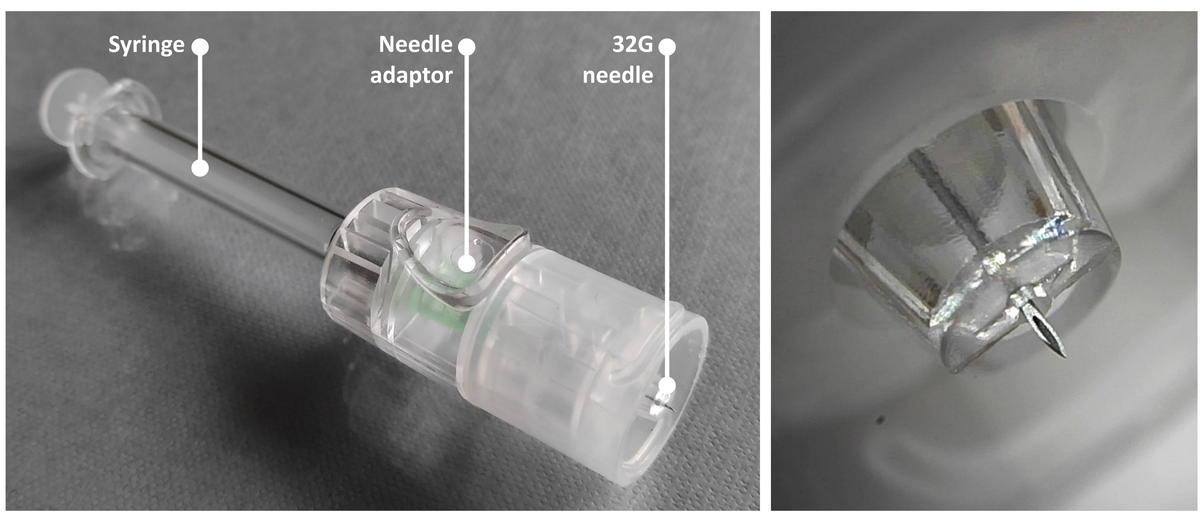
Intradermal injection has gained renewed interest due to its dose-sparing potential in light of the recent Sars-CoV-2 pandemic and the mpox health emergency. Indeed, studies have shown that intradermal vaccination with up to 1/10th of the dose typically administered intramuscularly, can elicit a non-inferior immune response[1].

The aim of the study was to create a mathematical model of an intradermal injection at a predefined depth using novel intradermal drug delivery device VAX-ID® by (1) creating a model that allows defining injection versus penetration depth; (2) verifying the metrics in a verification setting using imaging-based technology; (3) validating the metrics in a preclinical setting in piglets.

2. MATERIALS & METHODS

2.1. VAX-ID®

The device is composed of a housing, a friction foot, a very short premounted hollow needle with a luer connection and a safety pin. To guarantee skin penetration at a predefined depth, VAX-ID has a friction and acceleration mechanism that prevents skin-tenting associated with external leakage.



Picture of VAX-ID®, a newly developed intradermal injection device, allowing reliable, accurate and standardized injection in the dermis with high ease of use.

2.2. Mathematical model

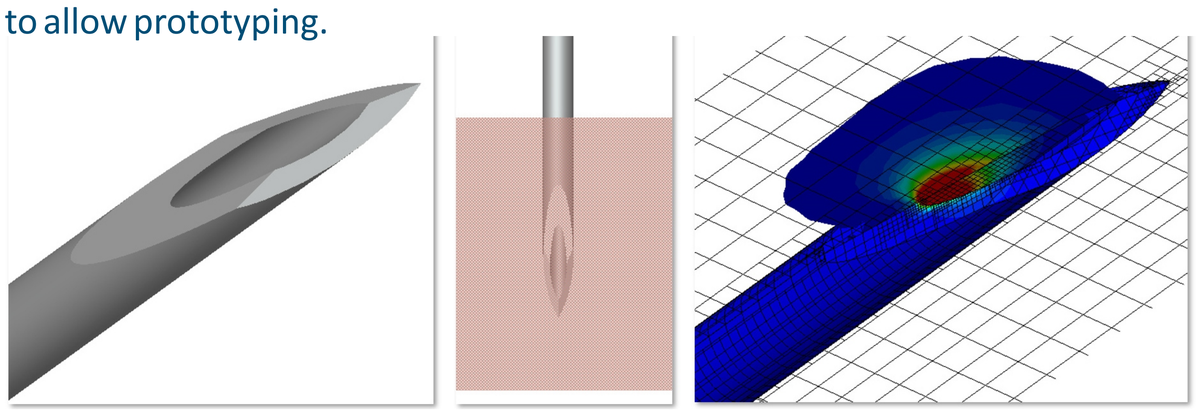
Several key elements of needles with gauge 32 and 30G were taken into account when building the model, including:

(1) primary bevel (e.g. 10°), secondary lancet (e.g. 60°) and tip cut angles (e.g. 19.2°); (2) the needle's outer diameter (0D); (3) inner diameter (ID); (4) wall thickness (WT); and (5) manufacturing tolerances;

These elements and parameters gave (i) a clear projected and (ii) tolerated range of the injection depth.

2.3. CAD model

To fully integrate these short needles, 3D CAD (Computer Aided Design) models of the needle geometry and the device components were configured, to allow prototyping.



CAD model of 32G needle for penetration assessment and Computational Fluid Dynamics (CFD)

2.4. Visual inspection

Consequently, injection molded prototype devices with needles compliant to ISO 7864:2016[2] were built. Pixel based imaging technology was used to assess the protruding needle length and investigate building tolerances.

2.5. Validation in piglets

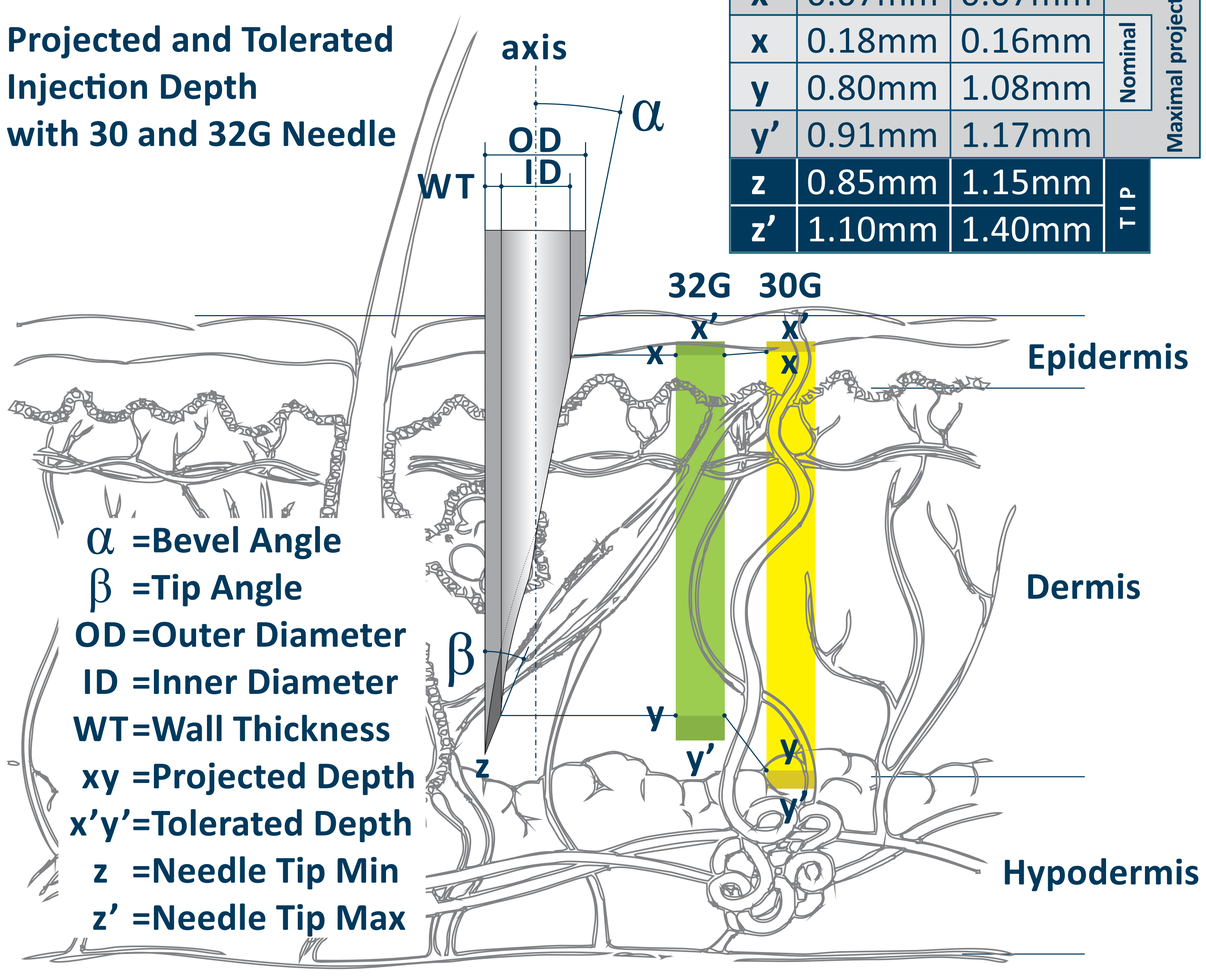
Finally, two piglets (12kg) received injections using VAX-ID® preconfigured with a 32G needle to gain pre-clinical evidence of injection depth.

3. RESULTS

3.1. Analytical assessment

Mathematical and computational analysis, taking +0/-0.25mm VAX-ID manufacturing allowance into account, gave clear theoretical values of (i) penetration and (ii) injection depth of a 30G and a 32G needle, whereby penetration depth always shows the larger value due to needle tip geometry.

	32G	30G	
x'	0.07mm	0.07mm	Maximal projected
x	0.18mm	0.16mm	Nominal
y	0.80mm	1.08mm	Nominal
y'	0.91mm	1.17mm	Maximal projected
z	0.85mm	1.15mm	TIP
z'	1.10mm	1.40mm	TIP



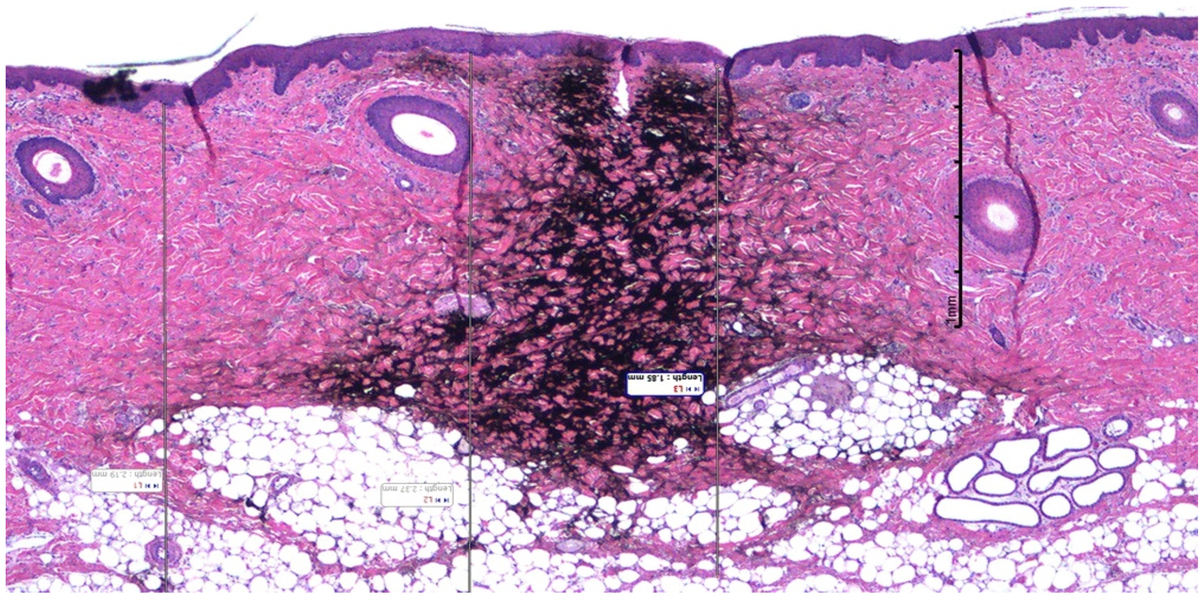
Scheme of projected penetration and injection depth of 30G and 32G needles.

3.2. Visual inspection

Visual inspection confirmed the protruding length of the tip on 100+ devices, making it an excellent tool for manufacturing or quality control purposes.

3.3. Validation in piglets

Equally, histology of piglet dermis of approximately 1mm thickness showed clear deposit of dye in the skin, without internal leakage to the hypodermis.



Histology results showing dye deposition in the skin post injection with VAX-ID 32G. H&E stain 20x

4. CONCLUSION

The predefined injection and penetration depth of the VAX-ID® needle has shown to allow for reliable intradermal injections. The mathematical model will enable different VAX-ID® variants targeting a variety of depths that can be used for a broad range of prophylactic and therapeutic vaccine applications.

5. REFERENCES

1. Hickling JK et al. World Health Organ. 2011
2. ISO 7864:2016