

Printing Anti-fungal Drugs onto Nails

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CONTEXT

Onychomycosis
(Nail fungal infections):

- 10% prevalence across the world
- 98% caused by *T. rubrum* (*Trichophyton rubrum*)
- current treatments 25%-30% relapse rate (Aggarwal et al., 2020)

OBJECTIVES

A novel design of double layer topical medicine will be achieved by 3D printing and its efficacy will be tested.

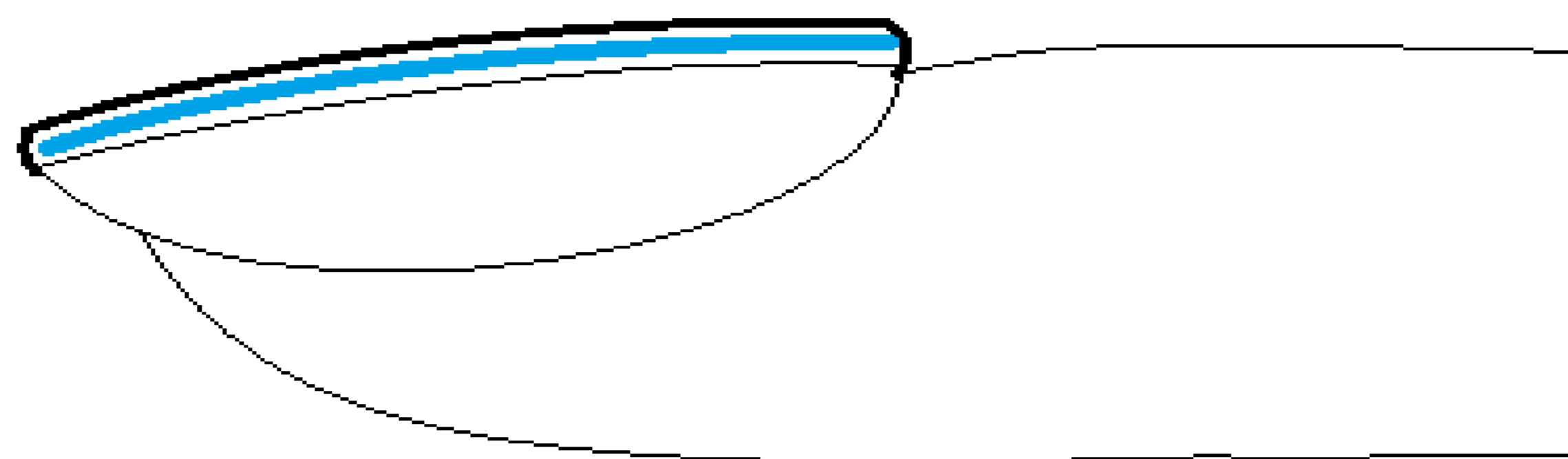


Fig.1 An occlusive film covers the antifungal gel in direct contact with infected nails to minimise drug loss and keep the nail plate hydrated.

- Topical treatment avoiding the systemic toxicity and associated side effects
- Maintaining hydration enhancing drug penetration
- Occlusive film minimising drug loss

METHODOLOGY

1. Printability of gels and film

$$Z = \frac{(\alpha\rho\gamma)^{1/2}}{\eta}$$

Z = printability
 α = the radius of cartridge orifice/m
 ρ = the density/ kg m⁻³
 γ = the surface tension/ N m⁻¹
 η = the viscosity/ Pa s

- Calculate printability Z and compare Z values with printable range [1 10] (Derby and Reis, 2003).
- Modify components by increasing the portion of ethanol if Z is too large.
- Plot a graph indicating changes in printability when ethanol percentage increases (printability against ethanol percentage).

2. Diffusion susceptibility test on discs and pre-infected nail plates

2.1 Disc Diffusion Test

Multiple layers of antifungal gels are printed onto 3 discs followed by printing of the film to 2 out of the 3 discs. This is to simulate the effect on actual nails illustrated by Fig. 1.

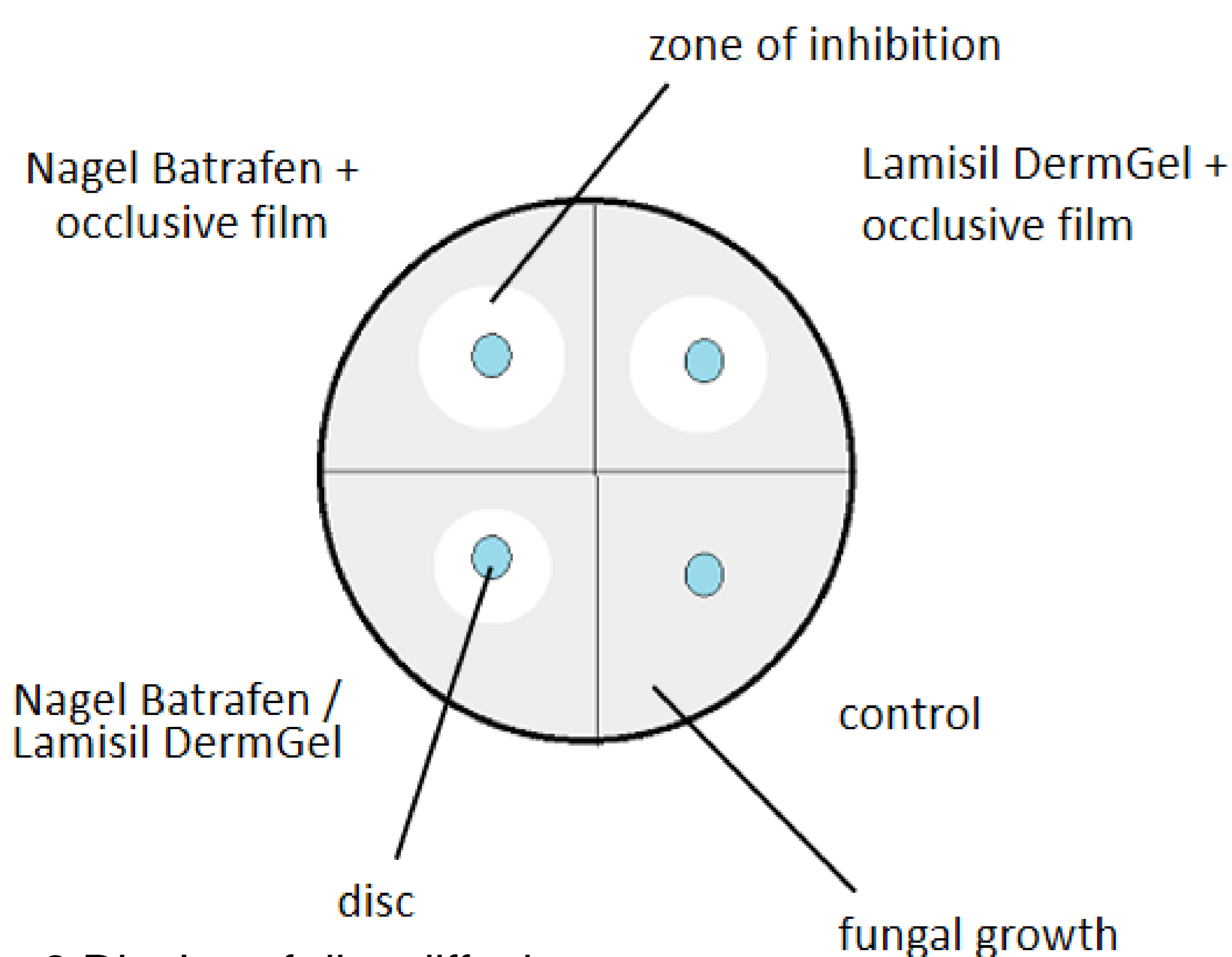


Fig.2 Display of disc diffusion test

Identifying the most efficacious drug combination and the optimal number of layers of drugs and films

2.2 Infected nail plate model diffusion test

Nails or nail substitutes are prepared and then pre-infected with *T. rubrum*.

The optimal number of layers of antifungal gels are printed onto 3 nail plate models followed by printing of the optimal number of layers of the film to 2 out of the 3 nail plate models. Stimulation of the treatment effect on actual nails illustrated by Fig. 1.

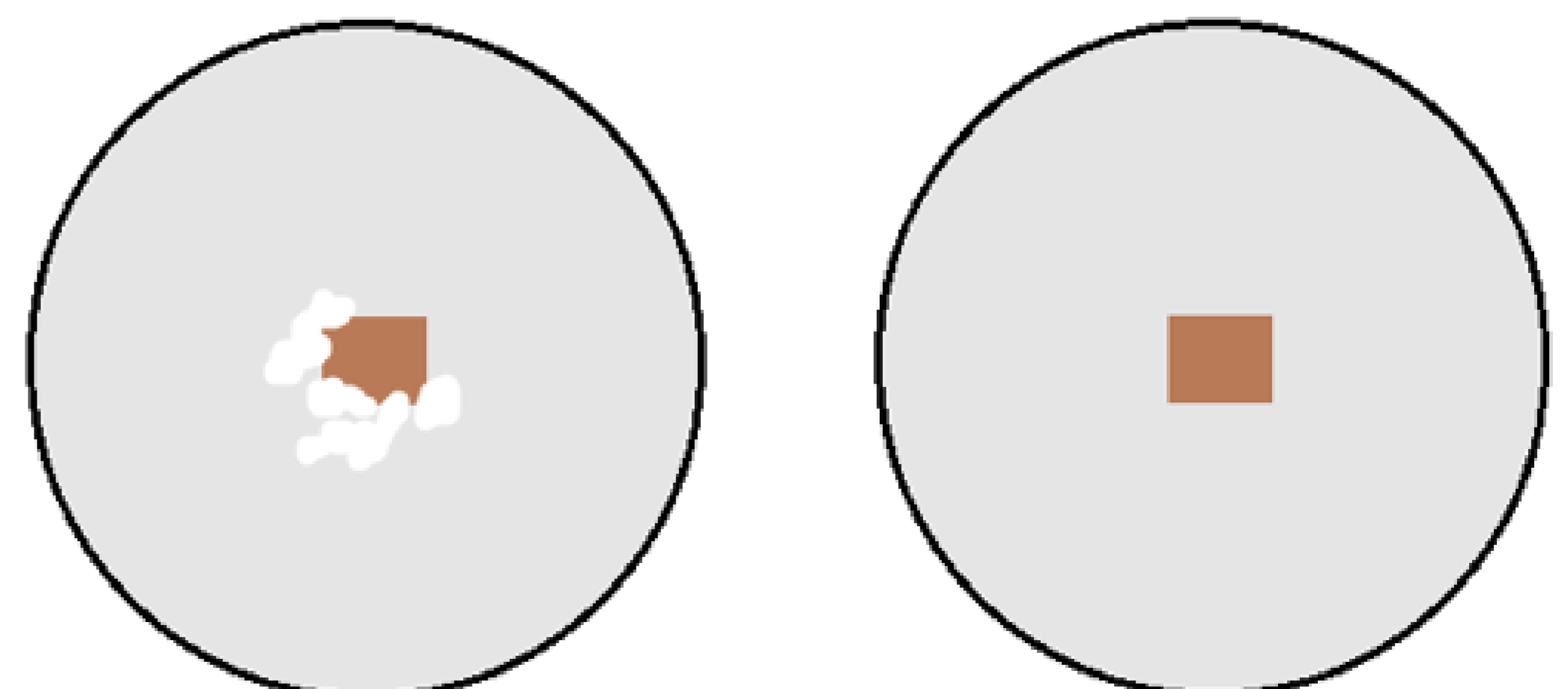


Fig.3 70% infected (left) vs 0% infected (right)

Percentages of the nail plate border with observable fungal growth predicates the effect of the medicine (Fig.3).

References

Aggarwal, R., Targotra, M., Kumar, B., Sahoo, P.K., Chauhan, M.K., 2020. Treatment and management strategies of onychomycosis. *J. Mycol. Médicale* 30, 100949.

Derby, B., Reis, N., 2003. Inkjet Printing of Highly Loaded Particulate Suspensions. *MRS Bull.* 28, 815–818.