

# Randomized feasibility trial of replacing or discarding the nail plate after nail-bed repair in children

A. Greig<sup>1</sup>, M. D. Gardiner<sup>2,3,4</sup> , A. Sierakowski<sup>8</sup>, C. J. Zweifel<sup>8</sup>, R. M. Pinder<sup>9</sup>, D. Furniss<sup>4,7</sup>, J. A. Cook<sup>5,6</sup> , D. Beard<sup>5</sup>, N. Farrar<sup>5</sup>, C. D. Cooper<sup>5</sup> and A. Jain<sup>3,4</sup>, on behalf of the NINJA Pilot Collaborative\*

<sup>1</sup>Department of Plastic Surgery, Guy's and St Thomas' NHS Foundation Trust, <sup>2</sup>Department of Surgery and Cancer, Imperial College London, and <sup>3</sup>Department of Plastic Surgery, Imperial College Healthcare NHS Trust, London, <sup>4</sup>Botnar Institute, <sup>5</sup>Royal College of Surgeons Surgical Intervention Trials Unit and <sup>6</sup>Centre for Statistics in Medicine, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, and <sup>7</sup>Department of Plastic Surgery, Oxford University Hospitals NHS Trust, Oxford, <sup>8</sup>St Andrew's Centre for Plastic Surgery and Burns, Mid Essex Hospital Services NHS Trust, Chelmsford, and <sup>9</sup>Department of Plastic Surgery, Hull and East Yorkshire Hospitals NHS Trust, Hull, UK  
Correspondence to: Mr M. D. Gardiner, Kennedy Institute of Rheumatology, Roosevelt Drive, Oxford OX3 7FY, UK (e-mail: matthew.gardiner@kennedy.ox.ac.uk)

**Background:** Nail-bed injuries are the most common hand injury in children. Surgical dogma is to replace the nail plate after repairing the nail bed. Recent evidence suggests this might increase infection rates and returns to clinic. The aim of this feasibility trial was to inform the design and conduct of a definitive trial comparing replacing or discarding the nail plate after nail-bed repair.

**Methods:** This study recruited participants from four hand units in the UK between April and July 2015. Participants were children under the age of 16 years with a nail-bed injury requiring surgery. They were randomized to either having the nail plate replaced or discarded after nail-bed repair. The follow-up method was also allocated randomly (postal *versus* clinic). Information was collected on complications at 2 weeks and 30 days, and on nail-plate appearance at 4 months using the Zook classification. Two possible approaches to follow-up were also piloted and compared.

**Results:** During the recruitment phase, there were 156 potentially eligible children. Sixty were randomized in just over 3 months using remote web-based allocation. By 2 weeks, there were two infections, both in children with replaced nail plates. The nail-replaced group also experienced more complications. There was no evidence of a difference in return rates between postal and clinic follow-up.

**Conclusion:** Recruitment was rapid and nail-bed repair appeared to have low complication and infection rates in this pilot trial. The findings have led to revision of the definitive trial protocol, including the mode and timing of follow-up, and modification of the Zook classification.

\*Members of the NINJA Pilot Collaborative are co-authors of this study and can be found under the heading Collaborators

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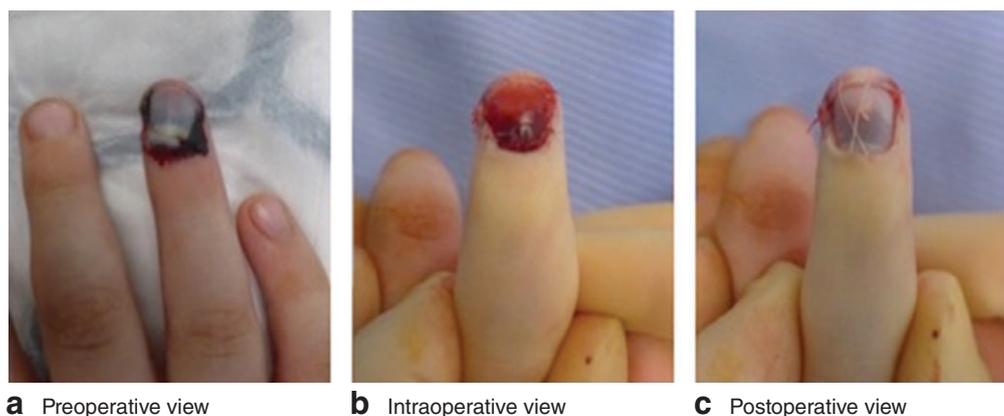
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## Introduction

Nail-bed injury is the most common paediatric hand injury requiring surgery. Typically, the injury is sustained when a child catches their fingertip in a closing door. This results in a laceration across the nail bed, which sits beneath the hard nail plate (fingernail). A tertiary hand surgery unit will expect to treat approximately four children each week. This equates to approximately 10 000 children treated annually

across the UK<sup>1</sup>. In the UK, 96 per cent of plastic surgery and orthopaedic hand surgeons replace the nail plate after repairing the nail-bed injury (*Fig. 1*)<sup>1</sup>. The rationale most often given for replacing the nail plate is that it protects the repaired nail bed and splints open the nail fold to enable normal nail growth. Recent evidence challenges surgical dogma by suggesting that replacing the nail plate results in higher infection rates, delayed wound healing and increased outpatient visits<sup>2</sup>. A recent Cochrane review<sup>3</sup>



**Fig. 1** Preoperative view of a fingertip injury with suspected nail-bed laceration. **b** The nail plate has been removed and the nail bed repaired with sutures. **c** The cleaned nail plate replaced into the nail fold and secured in position with a suture

highlighted the lack of high-level evidence in the management of these injuries.

A consensus meeting was held at the Royal College of Surgeons of England in February 2014 to discuss this clinical uncertainty. The meeting led to development of a trial protocol, but there were key methodological uncertainties that needed to be addressed. In light of this, a feasibility trial was undertaken with the aim of informing a large definitive trial to address the question of whether the nail plate should be replaced or discarded after nail-bed repair in children.

## Methods

This study received ethical approval from the National Research Ethics Service committee (15/LO/0067). It was carried out according to the principles of the Declaration of Helsinki and in accordance with the International Council for Harmonization Good Clinical Practice guidelines. The study was registered in the ISRCTN registry (ISRCTN16571591) and the full protocol has been published<sup>4</sup>. The study was on the UK Clinical Research Network Portfolio (ID 18516).

## Study design

The Nail bed INJury Analysis (NINJA) Pilot was an external feasibility study for a large pragmatic, multicentre RCT (NINJA Trial). Trial participants were prospectively recruited in the UK from the four participating National Health Service (NHS) Trusts: Guy's and St Thomas' Hospitals NHS Trust, London; Mid Essex Hospitals NHS Trust, Chelmsford; Hull and East Yorkshire Hospitals NHS Trust, Hull; and Oxford University Hospitals NHS

Trust, Oxford. Recruitment was undertaken between April and July 2015. All parents or guardians of children undergoing nail-bed repair were screened for the inclusion criteria and, if appropriate, approached to participate in the study.

## Eligibility criteria

Inclusion criteria were: aged below 16 years; acute nail-bed injury (occurring within 48 h of presentation at trial centre) requiring surgical repair; injury type included sharp lacerations, stellate lacerations, crush and avulsion injuries of the nail bed, injuries involving the sterile and/or germinal matrix, and nail-bed injuries with an associated pulp laceration and/or with an associated 'tuft' fracture of the distal phalanx; and children whose parent or legal guardian consented to their inclusion in the trial and were willing to return for follow-up.

Children presenting with a nail-bed injury that was already infected were excluded, as were those with underlying nail disease or deformity before the injury; children with an associated distal phalanx fracture requiring fixation with a Kirschner wire (this was considered to be another potential source of infection and therefore a confounding variable); children with complete amputation of the distal fingertip including all or part of the nail bed, which required repair as a composite graft or replantation; and children with loss of part or all of the nail bed requiring a nail-bed graft or flap reconstruction.

## Randomization

Children whose parents gave informed consent were randomized for the surgeon to either replace or discard the nail plate after nail-bed repair. Randomization was

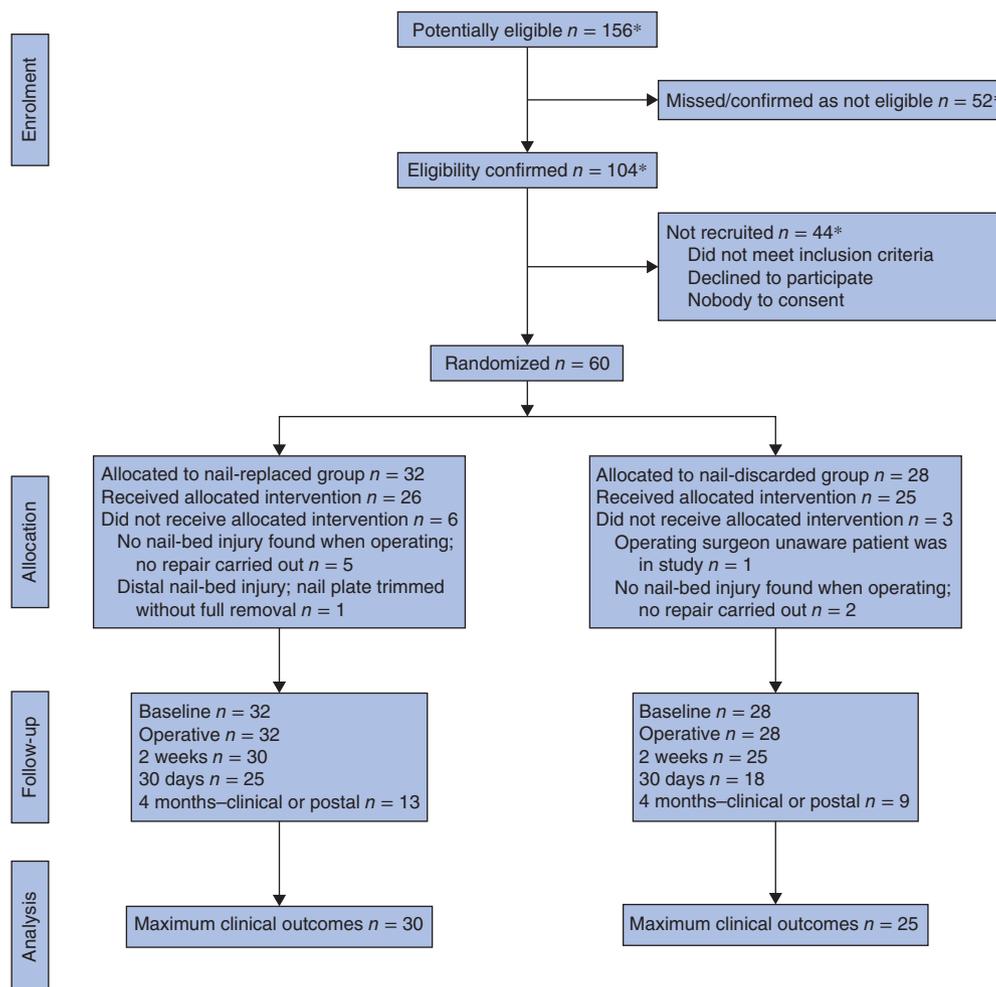


Fig. 2 CONSORT diagram for the trial. \*Full eligibility data were not available for one of the recruiting centres

undertaken by a web-based system provided by the Oxford Clinical Trials Research Unit, with allocation stratified by site and formed of random permuted blocks of varying size. Each participant received two allocations, one for treatment and one for method of follow-up at 4 months (postal or clinic). Randomization was undertaken shortly before surgery when the child was in the anaesthetic room.

### Outcome measures

The feasibility measures were: number of potentially eligible children; number of patients/parents and guardians approached to take part in the study; proportion of children for whom consent was sought who took part in the study; proportion of children who received the allocated treatment and reasons for any non-compliance; proportion of participants with a valid response at each follow-up point (for the 4-month time point both overall response rate and by method of follow-up).

The clinical outcome measures were: postoperative complications at 2 weeks and 30 days; pain experienced by the child at their first dressing change at 2 weeks (measured using the Wong–Baker FACES<sup>®</sup> Pain Rating Scale; Wong–Baker FACES Foundation, Oklahoma City, Oklahoma, USA); and the cosmetic (aesthetic) appearance of the nail at 4 months measured on a visual analogue scale using the Zook classification system<sup>5</sup>.

The secondary study objectives were to inform the design and conduct of the definitive NINJA Trial. Two blinded independent observers assessed the clinical photographs collected at the 4-month time point to allow an assessment of interobserver agreement.

### Statistical analysis

A total of 60 children were targeted for recruitment. A study of this size would be sufficient to generate a binary

feasibility measure with a 95 per cent confidence interval width of between 15 and 25 per cent, depending on the event proportion based on the Wald interval<sup>6</sup>.

Descriptive analyses of outcome data were carried out using appropriate summary measures. Outcome data were grouped according to the allocated intervention, irrespective of the actual treatment received. No imputation of missing data was performed; no children withdrew from the study. Binomial exact confidence intervals were calculated for the follow-up return rates, using the *cii* command across both treatment groups. Agreement between assessors was calculated for each component and the overall Zook appearance score. The overall score of assessors was also evaluated using weighted  $\kappa$  values with 95 per cent confidence intervals. The response rate between methods was compared according to the follow-up allocation by calculating the difference in percentage returned, with 95 per cent confidence intervals calculated using Newcombe's method<sup>10</sup>. All analyses were carried out in Stata release 14.1 (StataCorp, College Station, Texas, USA).

## Results

During the recruitment interval, between 21 April 2015 and 27 July 2015, a total of 156 children were potentially eligible, of whom 52 were missed or did not meet the inclusion criteria. Of the 104 that did, 44 were excluded. A total of 60 children were randomized, 32 to have the nail plate replaced and 28 to have it discarded (*Fig. 2*). Data on the number of children for whom a parent/guardian was approached about trial participation, but who declined, were not collected reliably and are not reported. The target recruitment was met within 97 days.

The clinical details of the children and their injuries are reported in *Table 1* and operative details in *Table S1* (supporting information). The groups were well matched in terms of age, mechanism of injury and perioperative care.

Compliance with the allocation was 85 per cent overall (*Fig. 2*). Six children in the nail-replaced group and three in the nail-discarded group did not receive the allocated intervention. The main reason for non-compliance was that no nail-bed injury was noted at the time of surgery.

Data completeness varied from excellent for baseline and operative data (100 (95 per cent c.i. 94 to 100) per cent for both), good for 2 weeks (92 (82 to 97) per cent), moderate for 30 days (72 (59 to 83) per cent) and poor for 4 months with either mode of follow-up (37 (25 to 50) per cent). Thirty-one children from the two groups were randomized to postal questionnaire follow-up and 29 to clinic review. Nine postal questionnaires were returned

**Table 1** Characteristics of the children and finger injuries

	Nail replaced (n = 32)	Nail discarded (n = 28)
Age (years)*	5.8(3.8) (< 1 to 16)	5.8(3.3) (1–14)
Sex ratio (F : M)	14 : 18	15 : 13
Right hand injured	15	17
Study digit		
Thumb	7	4
Index	4	5
Middle	12	8
Ring	4	8
Little	5	3
Mechanism		
Avulsion	2	1
Crush	28	25
Laceration	2	2
Other	0	0
Injury contaminated	1	0
Antibiotics started in emergency department	24	20
Medical condition		
Diabetes	0	1
Psoriasis	1	0
Unrelated conditions	2	5
None	29	22
Regular preoperative medication		
Insulin	0	1
Methotrexate	0	1
Antibiotic	0	2
Drug for related conditions	4	3
None	28	21

\*Values are mean(s.d.) (range).

and 13 patients came back for clinic review. There was no evidence of a difference in return rates between postal and clinic follow-up (–16 (–38 to 8) per cent).

## Clinical outcomes

During the first 2 weeks, two children were treated with antibiotics for wound infections. Although both children had the nail replaced, one was in the nail-discarded group (*Table 2*). The first child had no nail-bed laceration, received one additional course of antibiotics and was seen four times after surgery. The second child was randomized to have the nail discarded (protocol deviation), had two additional courses of antibiotics and was seen ten times after surgery.

Between 2 weeks and 30 days there was little apparent difference between the two groups (*Table 3*). There were no additional infections and the two reported before 2 weeks had resolved. There were four additional unplanned dressing changes during this interval, two in each group.

At 4 months, there were no additional treatments required by children in either group (*Table 4*). Of the

**Table 2** Postoperative outcomes at 2 weeks

	Nail replaced (n = 30)	Nail discarded (n = 25)
Postoperative problem†	16	9
Dressing change required	8	9
Fever	1	0
Pain	7	0
Rash	1	0
Allergic reaction to dressing	0	1
Infection	1	1
Light-headedness	0	1
Additional treatment‡	13	9
Analgesia	3	0
Oral antibiotics	1	1
Antihistamine	1	0
Antipyretics	1	0
Dressing change	8	9
Duration of antibiotics (days)*	7 (5–7)	7 (6–7)
Patient-reported outcomes§		
No pain before dressing change	23 of 24	16 of 24
No pain during dressing change	13 of 28	12 of 24

\*Values are median (i.q.r.). †Two participants in the nail-replaced group had two problems, and one participant had two and one had three problems in the nail-discarded group; ‡one participant in both groups had two treatments. §Assessed using the Wong–Baker FACES® Pain Rating Scale.

**Table 3** Postoperative outcomes at 30 days

	Nail replaced (n = 25)	Nail discarded (n = 18)
Postoperative problem*	4	3
Dressing change required	2	2
Infection	0	0
Pain	3	1
Additional treatment	2	2
Antibiotic	0	0
Dressing change	2	2

\*One participant had two problems (dressing change required and pain).

children seen in the clinic, one complained of pain and another developed an unrelated rash that resolved with treatment from the family doctor.

During clinical assessment of nail-plate growth in children returning to clinic at 4 months, the clinicians scored six of nine children as having an identical nail shape to that of the opposite uninjured finger in the nail-replaced group and three of four in the nail-discarded group (Table S2, supporting information).

The blinded independent observer scores showed no significant difference between the two groups (Table S3, supporting information). The limited parental assessment of nail-plate growth, using a visual analogue scale, suggested normal growth for all children in both groups.

There was no evidence of a difference between assessor 1 and 2 summary Zook scores for returned photographs at

**Table 4** Postoperative outcomes at 4 months

	Nail replaced (n = 9)	Nail discarded (n = 4)
Postoperative problem	1	0
Pain	1	0
Infection	0	0
Any additional treatment	0	0
VAS score for nail appearance*		
Parent	100 (70–100)	100 (88–100)
Patient	100 (60–100) (n = 5)	n.r.

\*Values are median (i.q.r.). Of 16 patients in the nail-replaced group and 13 in the nail-discarded group randomized to follow-up in the clinic, nine and four respectively returned for clinic review at 4 months. VAS, visual analogue scale (0, worst possible; 100, normal); n.r., not recorded.

4 months (25 children in total). Nail-shape and nail-surface components had the lowest level of agreement (36 and 48 per cent), whereas adherence, eponychium and split components had a higher level of agreement (72, 88 and 100 per cent respectively). The overall score agreement between assessors was 40 per cent. The weighted  $\kappa$  value was 0.36 (95 per cent c.i. 0.09 to 0.68).

## Discussion

The NINJA Pilot was a prospective multicentre RCT undertaken in paediatric nail-bed repair, and the first delivered by the Reconstructive Surgery Trials Network. Surgeons within the network were able to recruit children successfully in a short time. The rate of recruitment suggested that a definitive multicentre trial recruiting across the network would be able to enrol sufficient participants for a definitive trial to be able to assess key outcomes.

Compliance was reasonably high, although the number of children who did not have a nail-bed injury when examined during the operation was greater than anticipated. With regard to the definitive study, there are two main possible strategies to address this: to define the intervention as replacing or discarding the nail if a nail-bed repair is appropriate when examined during surgery, or to randomize during the operation once the nail-bed injury has been confirmed. The former is a more practical option. The latter is more desirable scientifically, but is not practical in an operating theatre.

The overall follow-up rate was good at 2 weeks (92 per cent), but only moderate at 30 days (72 per cent). At 4 months, both the clinic and questionnaire response rates were substantially lower than expected under either follow-up method. Given the low complication rates at the early time points, it is likely the parents felt no need to return to the clinic. Subsequent public and patient engagement activities have provided ideas as to how this can be

improved in the definitive trial using information technology and other approaches.

The agreement between assessors for the Zook classification-based cosmetic appearance score was poor. Disagreement was mainly in two of the component scores. The definitive trial requires a modified version of the score, which will offer greater consistency between assessors. Additionally, training of assessors is required to reduce inter-rater variability.

The present study suggests that surgery to repair nail-bed injuries in children is generally successful, with a low complication rate. The current dogma is to replace the nail plate after nail-bed repair. However, children with the nail replaced had both the reported infections and experienced complications typically requiring dressing changes and clinic visits.

Children in the nail-replaced group were more likely to experience pain in the first 2 weeks, but registered pain less often immediately before the dressing change. Half of the children in each group had pain immediately after the dressing change at 2 weeks. By 30 days there were few additional problems and at 4 months the nails in both groups had regrown with minimal deformity.

The next step is to complete a definitive RCT; this pilot has been crucial in refining the protocol and ensuring that the next study is appropriately powered.

### Collaborators

Members of the NINJA Pilot Collaborative who collaborated in this study: R. Agha, W. Albadry, Y. Cemal, P. Chadha, D. Collins, H. Creasy, A. Din, M. Ferreira, F. Maggiulli, A. Mitsakos, A. Molina, T. Pampiglione, M. Pywell, K. Richards, Y. Tavsanoğlu, R. Tejero, S. Vamadeva, R. Wang, M. Wordsworth (Guy's and St Thomas' NHS Foundation Trust, London); W. Holmes, J. Haeney, N. Brierley, E. Pardoe, C. Naylor (Hull Royal

Infirmery, Hull); T. Laing, I. Delikonstantinou, N. Whybro, H. Gerrish (Mid Essex Hospital Services NHS Trust, Chelmsford); E. Gammin (Oxford University Hospitals NHS Trust, Oxford).

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*Disclosure:* The authors declare no conflict of interest.

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### Supporting information

Additional supporting information may be found online in the supporting information tab for this article.