



## How does non-nutritive sucking support infant feeding?



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### ABSTRACT

Fifty nine premature infants participated in a randomized controlled study to determine the effectiveness of non-nutritive sucking (NNS). It was predicted that NNS would not accelerate the development of full oral feeding or early language skills as sometimes perceived in practice. However, it was predicted that using NNS as a strategy to support parents to identify and respond to early communication and oral readiness signs would increase confidence in infant management and enable quicker discharge home. Infants were aged 26–35 weeks gestation. Infants with no significant difficulties were randomly assigned to one of three groups; Group 1, NNS pre-tube feeding ( $n = 19$ ); Group 2, NNS on onset of tube feeding ( $n = 20$ ) and Group 3, Control ( $n = 20$ ). Follow-up occurred at 6 months. There were no significant differences with number of days to full oral feeding between the groups receiving NNS and the Control group,  $\chi^2(2, n = 59) = 4.33, p = .115$ . A significant difference in number of days in hospital between the Control group and the other two groups was found  $\chi^2(2, n = 59) = 7.678, p = .022$ . Significant changes were noted with the development of more normal sucking patterns in Groups 1–3. At 6 months there were no significant differences in receptive or expressive language skills between all groups. NNS had no significant impact on the transition to full oral feeding or later language development. There was a significant difference in the number of days in hospital between the Control group and the other two groups which involved parents in identification of early communication signs. Possible reasons for this change and future directions are discussed.

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## 1. Introduction

This paper considers using non-nutritive sucking (NNS) to support transition to full oral feeding for infants. There are many methods of administering NNS in the literature and these are often a prescribed programme of oral-motor and sensory exercises implemented by a health care professional which do not involve parents (Barlow, Finan, & Lee, 2008; Boiron, Da Nobrega, & Roux, 2007; Fucile, Gisel, & McFarland, 2011; Gaebler & Hanzlik, 1996; Hwang, Vergana, & Lin, 2010; Pimenta, Moreira, & Rocha, 2008; Rocha & Lopes Moreira, 2006). The focus of this study is from a speech and language therapy and nursing perspective and it recognizes the benefits that NNS can have. It is novel as it concentrates on training parents to use NNS in its simplest form as a tool to guide the infant to a state for effective early feeding. Therefore, the main focus of this study is about understanding the importance of an infant's early communication as well as exploring how NNS is effective. This approach fits well within the Developmental Care model of interpreting the infant's needs (Als, 1986). Some

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**Table 1**  
Baseline characteristics of infants in the three groups.

	Population		
	Group 1 NNS pre-NGT feeds (n = 19)	Group 2 NNS on onset NGT feeds (n = 20)	Group 3 Control (n = 20)
GA: 26–29 wks	5	4	10
GA: 26–29 birth weight range in g	990–1042	1325–1420	762–1325
GA: 30–35 wks	14	16	10
GA: 30–35 birth weight range in g	1684–2053	1480–2202	1082–2850
Sex: male	12	10	12
Sex: female	7	10	8

GA = Gestational age; NNS = Non-nutritive sucking; NGT = Nasogastric tube; Gms = grammes.

of the literature published about NNS suggests that it can hasten oral feeding skills, and also have benefits in overall oral-motor development (Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Gaebler & Hanzlik, 1996; Hwang et al., 2010; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006). Indeed, Boiron et al. (2007) state that “Non-nutritive sucking promotes the coordination of sucking and swallowing, accelerates the maturation of the sucking reflex. . . improves the initiation and duration of the first nutritive sucking.” (p. 439). This study explores the impact of NNS when parents are trained to use it. It makes the hypothesis that the identification of infant states and early communication is the strategy that can help infant development rather than using a pacifier to stimulate oral motor movements. Culturally, there is an anecdotal assumption that oral motor stimulation will have automatic nutritive, non-nutritive and communication benefits.

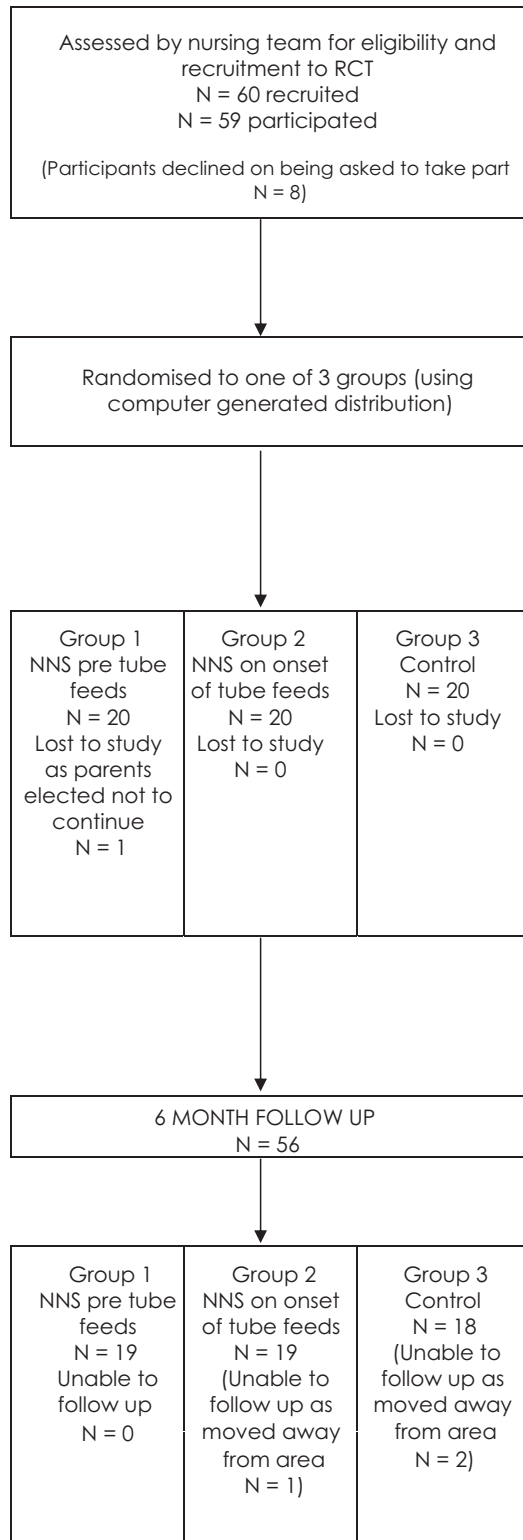
Establishing successful oral feeding for premature infants is challenging due to neurological immaturity, inconsistent physiological stability and limited ability to demonstrate non-verbal communication (Hanson & Landmesser, 2003; Harding, 2009). Mis-interpretation of pre-feeding and oral readiness behaviours can interrupt the introduction of effective feeding (McGrath & Medoff-Cooper, 2002; Pickler, Best, & Reyna, 2006). Oral feeding success in premature infants is associated with the increased development of the [quiet alert] state using NNS (McGrath & Medoff-Cooper, 2002; Pickler et al., 2006; White-Traut, Nelson, & Salvestrini, 2002). Non-nutritive sucking (NNS) and nutritive sucking (NS) are used as indicators of an infant's oral-motor status and behavioural state (Amaizu, Shulman, & Schandler, 2008; Bingham, Ashikaya, & Abbasi, 2010; Mizuno & Ueda, 2006). Nutritive sucking is the process of obtaining nutrition with a rate of one suck per second, whereas NNS occurs at two sucks per second in the absence of milk (Wolff, 1959). Many NNS programmes focus on 12–15 min of intensive oral motor work completed by a researcher (Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Hwang et al., 2010; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006). The notion that NNS will facilitate development of NS through strengthening of the muscles or neurological stimulation dominates these approaches (Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Gaebler & Hanzlik, 1996; Hwang et al., 2010; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006). This is an interesting idea given that neurological research highlights that activation sites for both nutritive and non nutritive oral motor skills are distinct (Bennett, Van Lieshout, & Pelletier, 2009; Jean, 2001; Martin, Goodyear, & Gat, 2001; Perry, Anderson, & Lean, 2002). It is however possible to develop NNS abilities, but not be able to progress onto NS (Harding, Frank, Dungu & Colton, 2012). Some papers focus on using NNS to involve parents in recognizing infant communication (Harding, Frank, Dungu, & Colton, 2012; Harding, 2009; Mizuno & Ueda, 2006), to calm infants with neurodisability (Coker-Bolt, Jarrad, Woodward, & Merrill, 2012; Harding et al., 2012) and to develop the [quiet alert] state for oral feeding (McGrath & Medoff-Cooper, 2002; Pickler et al., 2006; White-Traut et al., 2002). One directly refutes the idea that NNS can facilitate NS, suggesting that work on swallowing rather than sucking is more beneficial due to the earlier development of swallowing (Lau & Smith, 2012) (Fig. 2).

The following study predicted that NNS provided by parents would support improved carer interpretation of infant non-verbal signals of oral readiness but not decrease the time to achieve full oral feeding. In contrast to perceived link between nutritive, non-nutritive and language development through oral-motor work, this study also predicted that NNS would have no impact on the transition to full oral feeding or later language development. At times, there are difficulties with establishing parent-infant bonding, especially when there are medical and / or feeding problems (Als, 1986). In this context, NNS is seen as a way of supporting the parents to develop interaction with the infant (Harding et al., 2012).

## 2. Methods

### 2.1. Subjects

Infants included in the study were born between 26 and 35 weeks gestation and were recruited from a level 1 inner city neonatal unit (level 2 at onset of study) for this randomized non-blinded controlled study. Infants were excluded if they were identified as having congenital disorders, intraventricular haemorrhages III or IV, severe respiratory problems or necrotizing enterocolitis. Sixty eight parents were invited to participate, and 60 agreed to participate (Fig. 1). Ethical approval was gained from the NHS committee at the Royal Free Hospital, London. Parents were informed of the study with relevant information, and informed signed consent was obtained.



**Fig. 1.** Diagram of the participant allocation procedure.

<p>Peri-oral stimulation (Rationale – to improve muscle intractability, strength and orientation reflexes)</p> <ul style="list-style-type: none"> <li>• Cheeks x 4 (2 minutes)</li> <li>• Upper lip x 4 (1 minute)</li> <li>• Lower lip x 4 (1 minute)</li> <li>• Upper and lower lip curl x 2 each lip (1 minute)</li> <li>• Upper gum x 2 (1 minute) (rationale = to stimulate swallow &amp; improve suck)</li> <li>• Lower gum x 2 (1 minute) (rationale = to stimulate swallow &amp; improve suck)</li> <li>• Internal cheek x 2 each cheek (2 minutes)</li> <li>• Lateral borders of the tongue x 2 each side (1 minute)</li> <li>• Mid-blade of the tongue x 4 (1 minute) (rationale = to stimulate swallow &amp; improve suck)</li> <li>• Elicit a suck with finger (no frequency specified) (1 minute) (rationale = improve suck and soft palate activation)</li> <li>• Elicit a suck with pacifier (no frequency specified) (3 minutes) (rationale = improve suck and soft palate activation)</li> <li>• <b>TOTAL TIME = 15 minutes</b></li> </ul>
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Fig. 2. NNS programme cited in [Fucile, Gisel, & McFarland \(2011\)](#).

## 2.2. Setting and procedure

A computer generated randomization assigned infants to one of three groups; Group 1, NNS pre onset of tube feeding; Group 2, NNS on onset of tube feeding and Group 3, in which infants received the usual Developmental Care approach (Control) ([Als, 1986](#)) ([Table 1](#)).

Infants received the intervention once they started to show signs of oral readiness. The target was to engage infants in the programme for a minimum of three times a day until they were taking all of their feeds orally. Parents were encouraged to implement the programme, though if the parents were unable to be present for one of the feeds nursing and therapy staff completed the intervention. Training and on-line verbal coaching from a speech and language therapist in the identification of key infant behavioural states and responses to these states before the intervention began and on onset of the study ([Als, 1986](#)) was provided. For those infants allocated to the NNS pre tube feeding, parents were encouraged to use a pacifier to elicit three sequential sucks and to encourage sequential sucking for a minimum of 5 min. Parents were taught how to use NNS to encourage a [quiet alert] state optimal for successful feeding. The same methodology was used for use of NNS on onset of tube feeding. The rationale for using NNS as an intervention to prepare and orientate an infant to a state suitable for feeding was based on the current literature ([Gaebler & Hanzlik, 1996](#); [McGrath & Medoff-Cooper, 2002](#); [Pickler et al, 2006](#); [White-Traut et al., 2002](#)). Outcomes were time taken to achieve full oral feeding, number of days in hospital, type of sucking pattern using the Neonatal Oral Motor Schedule (NOMAS; [Meyer-Palmer, 1993](#)), and the average age of gestation for oral feeding. The NOMAS ([Meyer-Palmer, 1993](#)) is an assessment tool used to differentiate between disorganized and dysfunctional sucking patterns. Disorganized sucking is frequently demonstrated by premature infants when they begin to feed and is characterized by three five-suck bursts with pauses between suck bursts. Dysfunctional sucking is usually demonstrated by unusual and inconsistent sucking movements rather than immature oral movements. This pattern may be indicative of more serious underlying difficulties ([Gewolb, Vice, Schweitzer-Kenny, Taciak, & Bosma, 2001](#); [Medoff-Cooper, 1991](#); [Meyer-Palmer, 1993](#)).

Follow up at 6 months identified the number of times infants were re-admitted to hospital, any difficulties arising with oral feeding and receptive and expressive language ratings through discussion with parents using the Pre-School Language Scales ([Boucher & Lewis, 1997](#)). Analysis of both non-parametric and parametric data used the Statistical Program for Social Sciences software (version 18.0, SPSS Inc., Chicago, IL, USA).

## 2.3. Sample size

For infants receiving the usual Developmental Care approach ([Als, 1986](#)) in the neonatal unit, the average time from onset of oral trials to full oral feeding was 18.8814 days, with an average gestational age of 35.01. It was calculated that a sample size of 64 infants was required to detect a decrease in the transition time to achieve full oral feeding of up to 7 days with a type 1 error of 0.05, a power of 80. [Tables 1 and 2](#) show the baseline characteristics of the infant participants recruited to the study. A final total of 60 infants were recruited to the study and 59 completed the intervention offered on the neonatal unit. Gestational ages of the infant participants ranged from 26 to 35 weeks.

**Table 2**  
Group distributions.

	Population		
	Group 1 NNS pre-NGT feeds ( <i>n</i> = 19)	Group 2 NNS on onset NGT feeds ( <i>n</i> = 20)	Group 3 Control ( <i>n</i> = 20)
Gender	12 males 7 females	10 males 10 females	12 males 8 females
Gestational age	Mean = 32.53 SD = 2.67	Mean = 31.60 SD = 2.01	Mean = 30.95 SD = 3.14
Birth weight	Mean = 1651.11 SD = 403.12	Mean = 1757.90 SD = 304.82	Mean = 167.65 SD = 648.68

**Table 3**  
Type of feeding on discharge.

	Population		
	Group 1 NNS pre-NGT feeds ( <i>n</i> = 19)	Group 2 NNS on onset NGT feeds ( <i>n</i> = 20)	Group 3 Control ( <i>n</i> = 20)
<i>N</i> = breast feeders	11	14	7
<i>N</i> = breast and bottle feeders	7	6	8
<i>N</i> = bottle feeders	1	0	5
<i>N</i> = tube + oral via breast	0	0	0
<i>N</i> = tube fed + oral via bottle	0	0	0

#### 2.4. Rater-reliability

A live sample of 10% of infants was blind-assessed between the first author and an independent clinician from another inner city hospital. Rating involved describing the sucking patterns (referring to the NOMAS; Meyer-Palmer, 1993) and behavioural states (Als, 1986) of a random selection of infants who were about to begin oral feeding or who had attained full oral feeding. Agreement for the sample was 100%.

### 3. Results

In total, 68 parents of infants were approached and informed about the study. Sixty infants were enrolled and 59 completed the first part of the study. At the 6 months follow up, data was gained on 56 infants. Of the infants who did not complete their participation in the study, 2 deteriorated with changes in health and did not progress with the intervention, and 2 moved away from the area.

There were no statistical differences in number of days to achieve full oral feeding between the three groups; Group 1 (*n* = 19); Group 2 (*n* = 20); Group 3 (*n* = 20),  $\chi^2(2, n = 59) = 4.33, p = .115$  (Kruskal–Wallis test). Number of days for these three groups ranged from 8 to 50 days with additional outcomes as follows; Group 1 = 19.7 days average; Group 2 = 16.5 days average; Group 3 = 23.9 days average. It is interesting to note that the intervention groups progressed towards oral feeding more quickly than the Control group although the difference was not significant.

Gestational age on onset of implementing oral feeding was mainly 34 weeks (45.6%), followed by 35 weeks (38.2%). On discharge, a variety of feeding methods were adopted (Table 3); the highest number of infants discharged home breast feeding were in Groups 1 and 2.

A significant difference in number of days in hospital between the Control group and the other two groups was found (Group 1, NNS pre tube feed (*n* = 19) mean rank = 21.74; Group 2 NNS on onset of tube feed, (*n* = 20) mean rank = 31.00; Group 3 Control, (*n* = 20) mean rank = 36.85;  $\chi^2(2, n = 59) = 7.678, p = .022$  (Kruskal–Wallis test). Re-admissions included; Group 1 (*n* = 1) at 10 days due to poor feeding; Group 2 (*n* = 1) due to a viral upper respiratory infection; Group 3 (*n* = 2), due to (i) respiratory infection; (ii) poor feeding leading to dehydration at 16 days of age (Table 4).

The Neonatal Oral Motor Schedule scores (NOMAS; Meyer-Palmer, 1993) evaluated normal, disorganized and dysfunctional sucking patterns for all infants pre-group allocation and on onset of full oral feeding. Groups 1–3 showed statistically significant increases (Wilcoxon Signed rank test) in the number of normal sucking patterns (Time 1, median = 7, IQR = 5–9; time 2, median = 10, IQR = 10–10,  $p < .001$ ). All groups showed significant decreases of disorganised features of sucking as they matured (Time 1, median = 7, IQR = 5–9; time 2, median = 0, IQR = 0–0,  $p < .001$ ).

Receptive and expressive language scores were evaluated using the Pre-School Language Scales (Boucher & Lewis, 1997). There was some variability (though this was not significant) between the three randomized groups; Group 1, *n* = 19, mean rank PLS expressive = 28.08; Group 2, *n* = 19, mean rank PLS expressive = 29.47; Group 3, *n* = 18, mean rank PLS expressive = 27.92 (Table 5).

Only parents who had had re-admissions in Groups 1–3 mentioned that feeding had been challenging at times. All parents who received the interventions within Groups 1 and 2 reported that the intervention helped to support their management of the baby. One parent also reported that she had not considered how important communication was in the day to day management of the infant.

### 4. Discussion

The numbers used in this study are small, but it raises some points which warrant further study. Unlike other studies (Amaizu et al., 2008; Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Hwang et al., 2010; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006) it has shown that NNS does not specifically enable the development of NS skills as there were no significant differences between Groups 1 and 3 in the number of days to achieve oral feeding. All infants in Groups 1–3 showed similar variations in normal and disorganized sucking before and on onset of intervention. Maturation of NS skills in terms of type of sucking pattern may have come about through the experience of oral feeding, however small the

**Table 4**  
Number of days in hospital and number of readmissions post discharge.

Experimental group	Number of days in hospital [mean/median/mode/SD/range]	Readmissions post discharge
Group 1 NNS pre-NGT (n = 19)	Mean = 36.84 Median = 22 Mode = 20 SD = 29.96 9–104	1
Group 2 NNS on onset NGT (n = 20)	Mean = 37.90 Median = 32 Mode = 32 SD = 13.94 23–64	1
Group 3 Control (n = 20)	Mean = 54.40 Median = 60.50 Mode = 11 SD = 28.62 11–110	2

amount, rather than using NNS. Additionally, NNS did not enable more rapid development of oral skills in relation to language development as there were no significant differences between receptive and expressive language scores for Groups 1–3 at 6 months. Four infants from Groups 1 to 3 were re-admitted during the first 6 months of life with a variety of difficulties that impacted on their feeding. Gestational age of these infants ranged from 29 to 35 weeks; all had unremarkable Apgar scores and none developed persistent feeding problems.

Feeding orally is influenced by many factors (Bingham et al., 2010; Medoff-Cooper, 1991; Wolff, 1959). Those who benefit most from NNS for transition to oral feeding are premature babies with no significant medical problems and it seems likely that success is not for the reasons hypothesized by the majority of the studies (Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Gaebler & Hanzlik, 1996; Hwang et al., 2010; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006). As a premature infant matures, their NS and NNS patterns increase in frequency (Mizuno & Ueda, 2006). This was illustrated in this study with a quicker time to oral feeding with higher gestational age. Developing swallowing through small amounts of NS has been demonstrated as being more effective than NNS (Lau & Smith, 2012). Non-nutritive sucking patterns do not change significantly on onset of NS although NS changes more dramatically (Gewolb et al., 2001; Medoff-Cooper & Ray, 1995). Infants with neurodisability can develop NNS but this does not automatically lead to the development of NS (Harding, Frank, Dungu & Colton, 2012). With normal infant development, NNS patterns remain static but NS patterns change. These two points seem to indicate that the neurological origins of NNS and NS are distinct, and therefore the rationale for using NNS needs careful consideration and re-evaluation (Clark, 2003; Ertekin, 2011; Gewolb et al., 2001; Medoff-Cooper & Ray, 1995).

Using a pacifier prior to or on onset of a tube feed along with verbal coaching from practitioners appears to be effective in supporting parents to understand early communication vital to interpretation of an infant's state. It therefore needs to be considered as a serious strategy to promote parent confidence when developing infant care skills. Use of NNS in an exercise format as described by Fucile et al (2011) does not involve any clear evaluation of infant pre-verbal states as such and consequently needs to be explored further in comparison to more informal methods that utilize parent skills in the development of infant feeding. In this study infants who received the NNS progressed home more quickly although there was no quicker progression to oral feeding or difference in early language development between the three groups. This tentatively suggests that using NNS possibly has some particular benefits for the development of parent confidence in the identification of their baby's needs. At present, it is difficult to be specific about why the intervention groups spent fewer days in hospital. Further studies could evaluate parent perceptions of infant states both pre-feeding and at other times during the day. Parent perceptions could be compared pre- and post training. Evaluation of parent identification and preparation of [quiet alert] states using NNS or not and time taken to achieve full oral feeding pre- and post training would yield more

**Table 5**  
Pre-language scales ratings at 6 months.

Experimental group	PLS receptive language (range 1–4)	PLS expressive language (range 1–4)
Group 1 NNS pre-NGT (n = 19)	n 19 = 4	n 17 = 4 n 1 = 3 n 1 = 2
Group 2 NNS on onset NGT (n = 20)	n 19 = 4	n 18 = 4 n 1 = 2
Group 3 Control (n = 20)	n 18 = 4	n 16 = 4 n 1 = 3 n 1 = 2

specific results, particularly if compared with other groups using different methods. This study appears not to support the literature which suggests that NNS developed through use of an oral-motor programme may lead to the quicker development of NS (Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Hwang et al., 2010; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006). Further research that compares more traditional exercise approaches with a parent based communication approach as demonstrated in this study is needed (Arvedson, Clark, Lazarus, Schooling, & Frymark, 2010; Barlow et al., 2008; Boiron et al., 2007; Fucile et al., 2011; Hwang et al., 2010; Medoff-Cooper & Ray, 1995; Pimenta et al., 2008; Rocha & Lopes Moreira, 2006).

### Author contribution

C.H. conceived the idea for the project, and L.F. and V.S. enabled it to happen. C.H. took the lead in preparing the manuscript, but L.F., V.S., K.H. and N.B. contributed to its final presentation.

### Ethics approval

Ethical approval was gained from the NHS/IRAS committee at the Royal Free Hospital, London.

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