

# Is it possible to Predict the Eventual Outcome of a Graf Type IIa Hip by Graphical Extrapolation?

Deirdre Walden\* MSc. HDMU, DCR

## Introduction

Developmental Dysplasia of the Hip (DDH) describes a problem with hip joint formation in children. The location of the problem can be either the hip joint (femoral head), the socket of the hip joint (the acetabulum) or both. Abnormal hip development or developmental dysplasia of the hip is the commonest problem found in a baby's musculo skeletal system.

As this is a developmental condition, often multiple scans are required to monitor the progress. The objective of this research was to investigate whether it is possible to reduce the number of follow up ultrasound scans by predicting the eventual outcome by graphical extrapolation techniques.

## Graf Technique

The Graf Technique (Graf, 2006) for the assessment of DDH was used. This assessment is based on the appearance of the acetabulum in a coronal neutral position and describes measurements of the alpha angle and beta angle which are found by drawing the following three lines and measuring the angles.

- The bony alpha angle is between the base line and lower limb of os and quantifies the bony socket.
- The cartilage beta angle is between the base line and the cartilage roof.

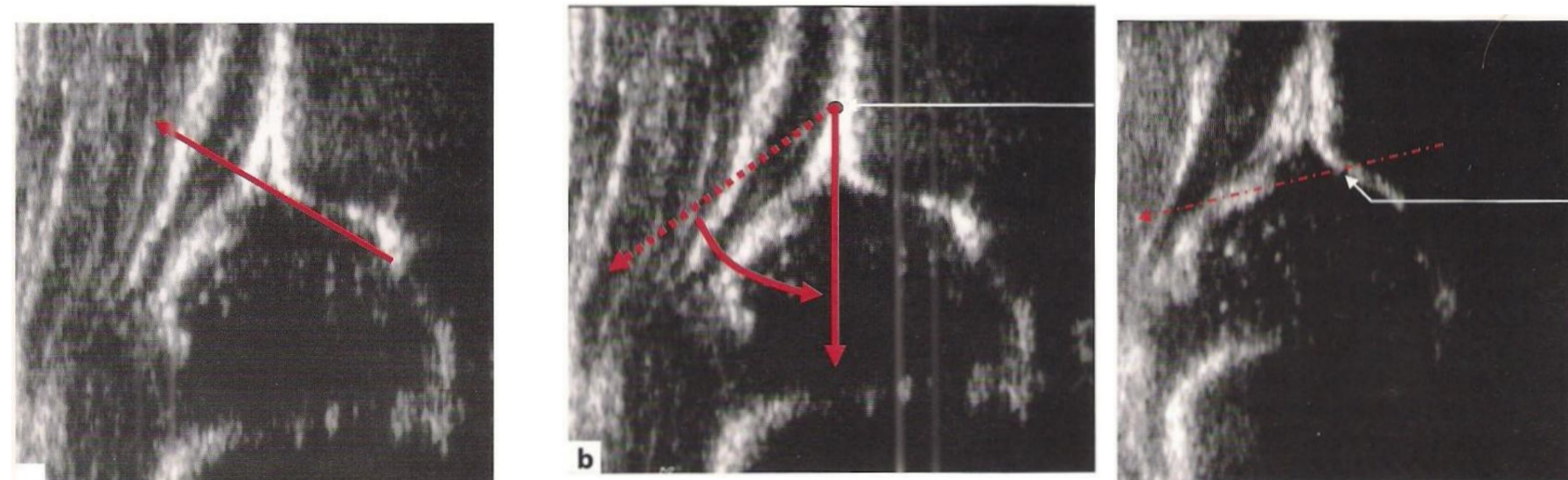


Figure 1: Acetabular Roof line

Figure 2: Base line

Figure 3: Cartilaginous Roof line

The acetabular roof line runs tangentially from the lower limb of the os ilium to the bony roof. The lower limb of os ilium is the depth of the acetabular fossa. The base line runs tangentially from the os ilium to the middle of the labrum. The cartilaginous roof line connects the osseous rim (turning point of concavity to convexity) with the middle of the labrum.

This study concentrated on the alpha angle.

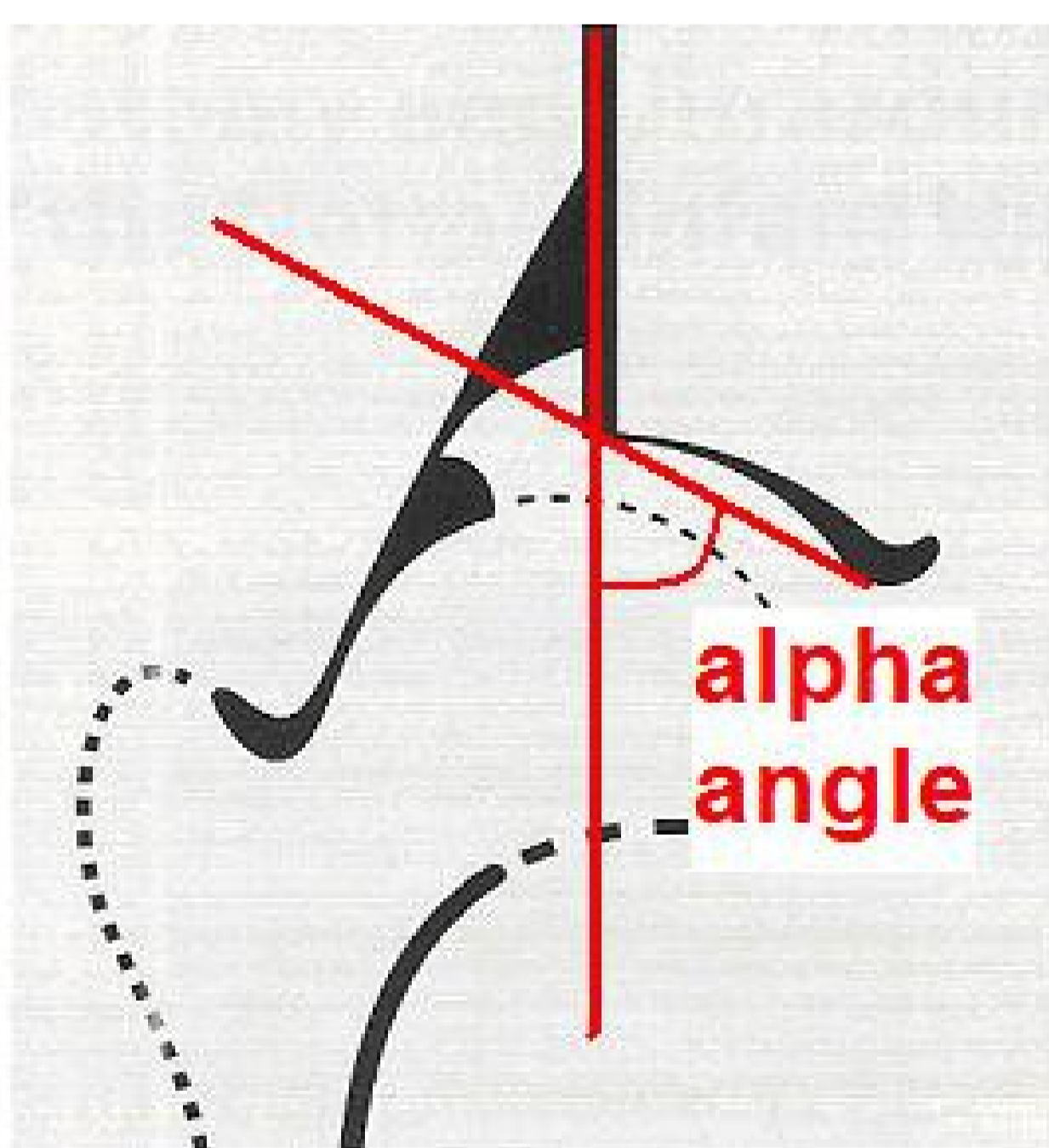


Figure 4: The Alpha Angle

Graf classifies infant hips into four main different types, largely by the alpha angle

| Alpha Angle  | Graf Classification | Description   |
|--------------|---------------------|---------------|
| 60° and more | Type I              | Mature Hip    |
| 43° to 59°   | Type II             | Immature Hip  |
| 42° and less | Type III or Type IV | Decentred Hip |

Table 1: Alpha angles and Graf Classification

For the purpose of this study, the progress of infants who presented with an immature hip at first scan was followed. Using graphical techniques, the alpha angle was plotted against time. It was then determined whether or not the development followed a linear progression.

244 Infants with high risk factors for DDH referred for hip sonography in a six month period were included in this study. Sonographic examinations were performed using the Graf technique. Both hips were measured and the Graf classification determined.

\* Currently employed at Princess Anne Hospital (UHS). Research undertaken for MSc. studies at the AECC, Bournemouth

## Results

A total of 257 infants have been recorded as having undergone hip ultrasound within the set period from the beginning of July 2013- to the end of January 2014. After the inclusion/exclusion criteria had been applied the total number of infants was reduced to 244. Of these 244 infants, 136 or 56% were female and 108 or 44% were male.

149 infants were reported as having a normal Graf Type 1 result for both hips at their four week scan and were discharged from Ultrasound Services. This accounted for 61% of the referrals. The remaining 95 infants or 39% were classed within the Graf Type II - Graf Type IV range and required either immediate treatment or follow-up scans. Two infants were either a Graf Type IIc, D, Type III or IV and were referred to Physiotherapy for immediate treatment.

72 were found to have had satisfactory acetabular maturation by the second scan (i.e. achieved a Graf Type I). 11 were referred on to the Physiotherapy department for the treatment with a Pavlik harness after the second scan. 9 were found to have had satisfactory acetabular maturation by the third scan and one was referred on to the Physiotherapy department for treatment. Of those infants requiring further evaluation, 81 matured to a Graf Type I within the 12 week period. 14 infants were referred to Physiotherapy for the application of a Pavlik harness during the 12 week period.

| Scan  | Type I | Type IIa | Type IIc - IV | Total scanned |    |      |     |
|-------|--------|----------|---------------|---------------|----|------|-----|
| 1st   | 149    | 61.1%    | 93            | 38.1%         | 2  | 0.8% | 244 |
| 2nd   | 72     | 29.5%    | 10            | 4.0%          | 11 | 4.5% | 93  |
| 3rd   | 9      | 3.7%     | 0             | 0             | 1  | 0.4% | 10  |
| Total | 230    | 94.3%    | 0             | 0             | 14 | 5.7% | 244 |

Table 2: Hip outcomes over three scans

For the 10 patients that had at least three scans performed, the alpha angle was plotted against the infant's age at the time of each scan using MS Excel. The author then used Excel's linear "Trendline" feature to extrapolate a predicted alpha angle at 12 weeks of age for each hip.

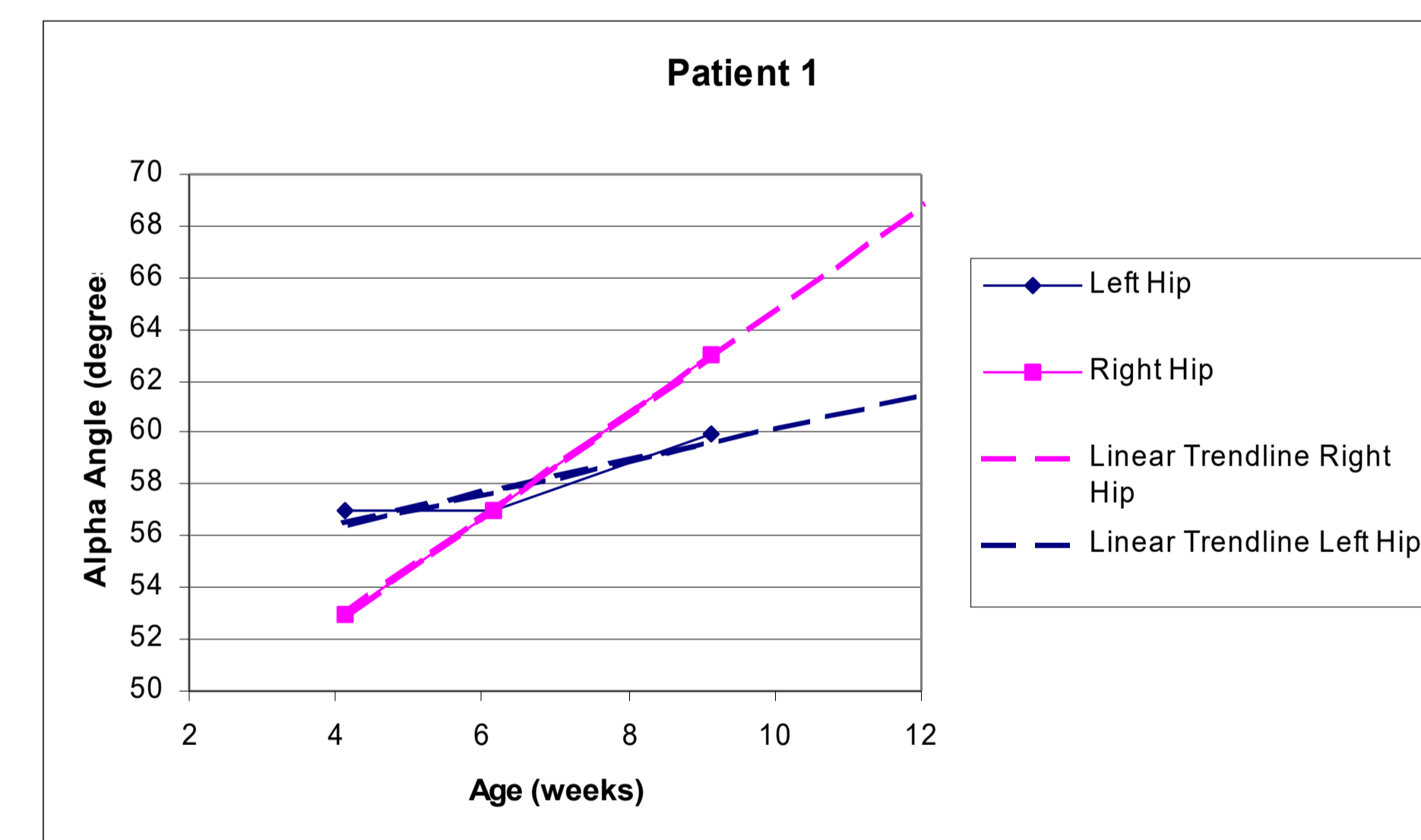


Figure 5: Alpha angle plotted against age for an example patient. Note the trendlines predicting maturation by 12 weeks

The predicted outcome was then compared to the clinical decision.

| Patient Number | Left Hip Clinical Decision | Right Hip Clinical Decision | Left Hip Graph Prediction | Right Hip Graph Prediction | Left Hip Agreement | Right Hip Agreement |
|----------------|----------------------------|-----------------------------|---------------------------|----------------------------|--------------------|---------------------|
| 1              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 2              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 3              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 4              | Type I                     | Type I                      | Treat                     | Type I                     | No                 | Yes                 |
| 5              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 6              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 7              | Treat                      | Type I                      | Treat                     | Type I                     | Yes                | Yes                 |
| 8              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 9              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 10             | Type I                     | Treat                       | Type I                    | Treat                      | Yes                | Yes                 |

Table 3: Comparison of clinical decision with predicted outcome at 12 weeks using linear maturation based on three scan results

Agreement was found between the clinical decision and the predicted outcome from the graph in 19 out of 20 cases. For the right hip agreement was 100% (10 out of 10) and for the left hip it was 90% (9 out of 10). Overall agreement was 95%.

For the 10 patients already discussed, the author then attempted to predict the outcome at 12 weeks by extrapolating the alpha angles from only two scans. This was done using either the first and the second scan (i.e. ~four weeks and ~six weeks) or either the first and the third scan (i.e. ~four weeks and ~eight weeks).

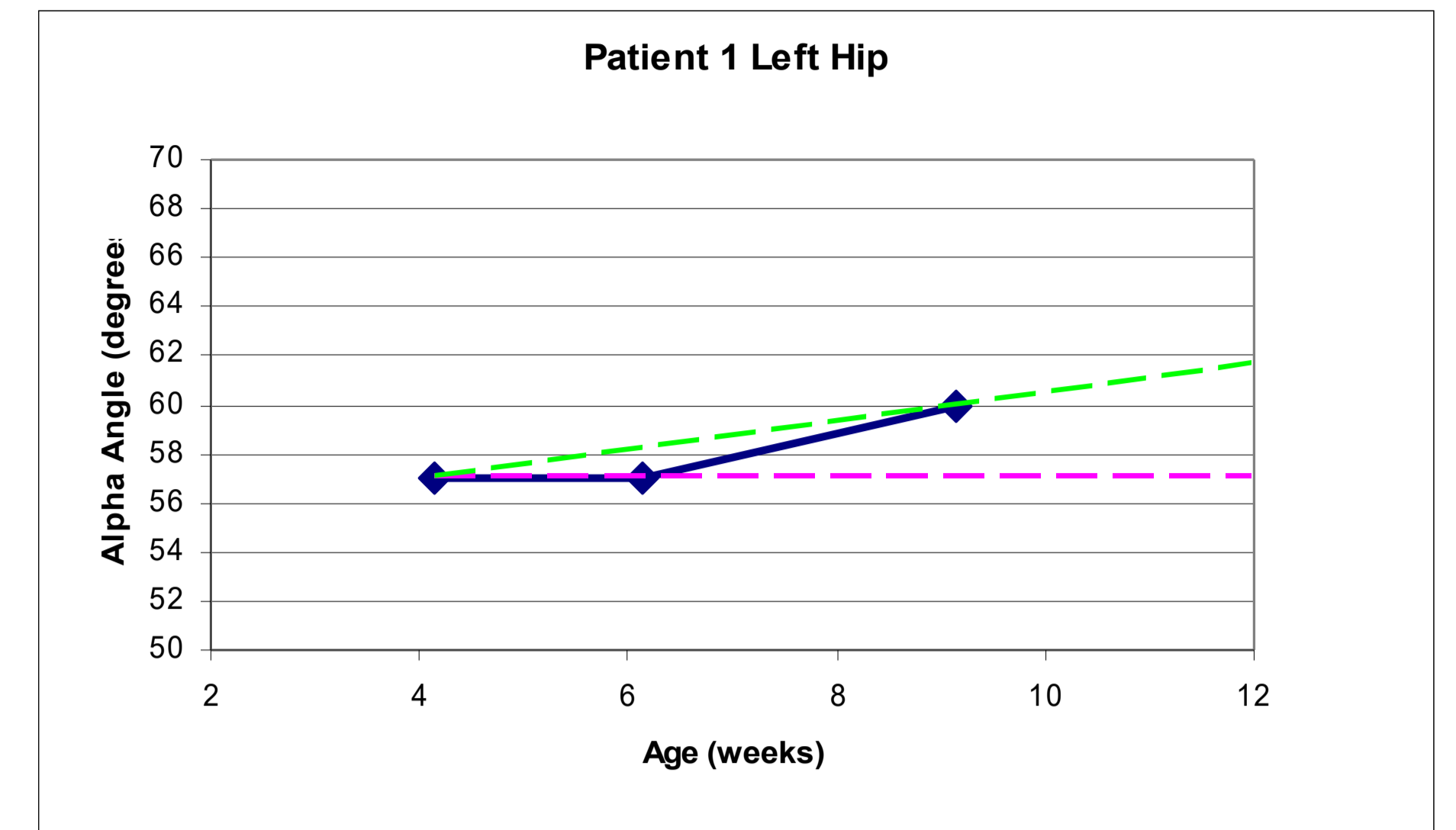


Figure 6: Alpha angle plotted against age for an example patient with predicted outcomes extrapolated from first and second (pink) and first and third (green) data points.

Note that in the example above the outcome found from extrapolating from the first and second data points (pink) predicts that the hip would not reach maturation by 12 weeks whereas the outcome found from extrapolating from the first and third data points (green) predicts that the hip would mature. The predicted outcome was again compared to the clinical decision. Results are shown in the following tables.

| Patient Number | Left Hip Clinical Decision | Right Hip Clinical Decision | Left Hip Graph Prediction | Right Hip Graph Prediction | Left Hip Agreement | Right Hip Agreement |
|----------------|----------------------------|-----------------------------|---------------------------|----------------------------|--------------------|---------------------|
| 1              | Type I                     | Type I                      | Treat                     | Type I                     | No                 | Yes                 |
| 2              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 3              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 4              | Type I                     | Type I                      | Treat                     | Type I                     | No                 | Yes                 |
| 5              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 6              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 7              | Treat                      | Type I                      | Treat                     | Type I                     | Yes                | Yes                 |
| 8              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 9              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 10             | Type I                     | Treat                       | Type I                    | Type I                     | Yes                | No                  |

Table 4: Comparison of clinical decision with predicted outcome at 12 weeks using linear maturation based on first and second scan results

Agreement was found between the clinical decision and the predicted outcome from the graph in 17 out of 20 cases. For the right hip agreement was 90% (9 out of 10) and for the left hip it was 80% (8 out of 10). Overall agreement was 85%. Predicting the outcome at 12 weeks using only the first and second scans gave a poorer agreement than the linear trendline discussed above.

| Patient Number | Left Hip Clinical Decision | Right Hip Clinical Decision | Left Hip Graph Prediction | Right Hip Graph Prediction | Left Hip Agreement | Right Hip Agreement |
|----------------|----------------------------|-----------------------------|---------------------------|----------------------------|--------------------|---------------------|
| 1              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 2              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 3              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 4              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 5              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 6              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 7              | Treat                      | Type I                      | Treat                     | Type I                     | Yes                | Yes                 |
| 8              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 9              | Type I                     | Type I                      | Type I                    | Type I                     | Yes                | Yes                 |
| 10             | Type I                     | Treat                       | Type I                    | Treat                      | Yes                | Yes                 |

Table 5: Comparison of clinical decision with predicted outcome at 12 weeks using linear maturation based on first and third scan results.

Agreement was found between the clinical decision and the predicted outcome from the graph in all 20 cases. For the right hip agreement was 100% (10 out of 10) and for the left hip it was 100% (10 out of 10). Overall agreement was 100%. Predicting the outcome at 12 weeks using only the first and third scans gave a better agreement than both the linear trendline and the prediction using only the first and second scans discussed above. Furthermore it gave the same result as the clinical decision.

## Conclusion

The author concludes that it is possible to accurately predict the outcomes for infants exhibiting Type IIa hips from two scans, providing an interval of at least four weeks between scans is used. This would reduce the number of follow up scans, reducing the pressure on the Ultrasound Service and reducing patient/parent inconvenience and anxiety and also should offer some cost saving. This study has proved that it is possible to successfully predict the eventual outcome of a Type II hip by graph extrapolation. It recommends that the initial scan should be performed at 6 weeks in infants who have clinically stable hips and that a follow up scan should be performed not less than 4 weeks later.

## Reference

Graf, R., (2006). Hip Sonography. Diagnosis and Management of Infant Hip Dysplasia. 2nd Edition. Springer.