

AN ICP-MS METHOD FOR MEASURING CHROMIUM AND COBALT IN WHOLE BLOOD FROM PATIENTS WITH METAL-ON-METAL HIP REPLACEMENT



Torill Kalfoss¹, Tor C. Borch^{2,3}, Stephan M. Rörl^{2,3}, Armin P. Piehler¹

¹Fürst Medical Laboratory, Oslo, Norway, tkalfoss@furst.no

²Department of Orthopaedic Surgery, Oslo University Hospital, Oslo, Norway

³Center for Implant and Radiostereometric Research, Oslo, Norway



Introduction

The Norwegian Arthroplasty Register and Norwegian Society for Hip and Knee Surgery recommend measuring the metal ions Chromium (Cr) and Cobalt (Co) in whole blood from patients with metal-on-metal (MoM) hip replacements (1). Increased levels of these metal ions are correlated with soft tissue necrosis and development of pseudotumors. The Medicines and Healthcare Products Regulatory Agency (MHRA, UK) has defined Cr and Co concentrations in whole blood above 7 µg/L as significantly increased demanding further action. The aim of this study was to establish an Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method for measuring Cr and Co in whole blood from patients with MoM hip replacements.

Materials and Method

An ICP-MS method for quantitative determination of Cr and Co in whole blood was developed at Fürst Medical Laboratory using a PerkinElmer Elan® DRC™ II instrument equipped with an ESI SC-4 FAST autosampler. ⁵⁹Co⁺ was measured in standard mode (without reaction gas) and ⁵²Cr⁺ was measured in DRC mode using NH₄. Ammonia was used to overcome the major spectral interferences from ⁴⁰Ar¹²C⁺, among others, on ⁵²Cr⁺. External calibration was used and the standard was matched with sample-matrix by adding Chromium (Cr) and Cobalt (Co) PerkinElmer Pure Atomic Spectroscopy Calibration Standards, Matrix 2 % HNO₃, 1000 µg/mL (Shelton, USA) to Autonom™ (Billingstad, Norway). Samples, standard and quality controls were diluted 1:20 with Milli-Q™ de-ionized water (Millipore, Bedford, MA, USA) with 0,1% (v/v) Nitric acid (65% m/v, Suprapur®, Merck, Darmstadt, Germany) and 0,5% (v/v) 1-Butanol (74,12 g/mol pro analysi, Merck, Darmstadt, Germany). 20 µg/L Rhodium (Rh) PerkinElmer Pure Atomic Spectroscopy Calibration Standard, Matrix 10% HCl, 1000 µg/mL (Shelton, USA) was added directly to the diluent and was used as an internal standard.

The method was evaluated by interlaboratory comparison with Inductively Coupled Plasma Sector Field Mass Spectrometry (ICP-SFMS) at ALS Scandinavia AB, Luleå, Sweden and external quality control scheme from TEQAS. Moreover, whole blood from 25 healthy controls and 25 patients with MoM hip replacements from the Department of Orthopaedic Surgery, Oslo University Hospital, were analyzed.

Results

Table 1 shows the obtained precision and limit of quantification of the developed method. Table 2 shows interlaboratory comparison with Inductively Coupled Plasma Sector Field Mass Spectrometry (ICP-SFMS) at ALS Scandinavia AB, Luleå, Sweden.

Table 2

Fürst	ALS
Chromium (µg/L)	
0,4	0,58 - 0,92
3,7	3,43 - 5,27
1,6	1,7 - 2,58
73,6	57,4 - 87,2
2,0	1,51 - 2,43
Cobalt (µg/L)	
0,7	0,48 - 0,73
4,7	3,75 - 5,57
1,6	1,36 - 2,06
200,1	171 - 253
1,7	1,54 - 2,34

Table 1

Chromium	
Precision, %CV (level 0,8 µg/L)	9,1
Precision, %CV (level 35,1 µg/L)	2,6
LOQ (µg/L)	0,3
Cobalt	
Precision, %CV (level 0,3 µg/L)	11,6
Precision, %CV (level 12,2 µg/L)	4,5
LOQ (µg/L)	0,2

Figure 1 and 2 show z-score of the results from external quality control scheme from UKNEQAS for Trace Elements, TEQAS, Surrey. A z-score within ±2 is acceptable.

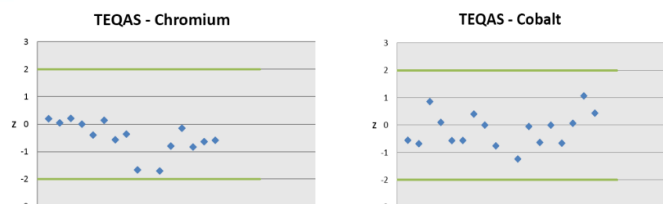


Figure 1

Figure 2

Figure 3 and 4 shows the results from 25 patients with MoM hip replacements from the the Department of Orthopaedic Surgery, Oslo University Hospital, compared with 25 healthy controls. Only one patient showed levels of Cr and Co above recommended levels. Patients with MoM hip replacements have consistently higher levels of Cr and Co in whole blood compared to healthy controls.

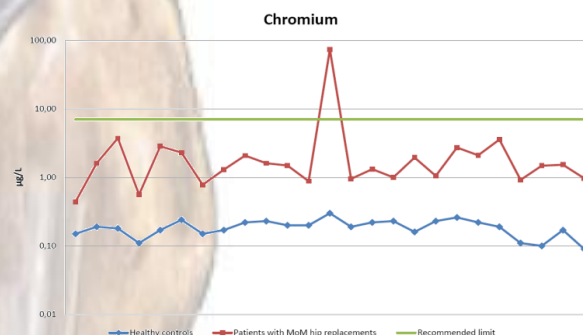


Figure 3

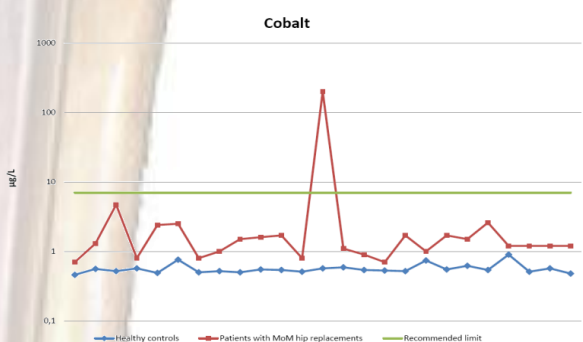


Figure 4

Discussion and Conclusion

The established ICP-MS method is valid for measuring Chromium and Cobalt in whole blood. Patients with MoM hip replacements have significantly higher concentrations of these metal ions in whole blood compared to healthy controls. However, metal ion concentrations above recommended limits are rare.

References

http://nrlweb.ihelse.net/Oppfølging_av_pasienter_med_metall-på-metall_hofteproteser._Anbefaling_fra_Nasjonalt_register_for_leddproteser.pdf