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Figure captions

TABLE I Chemical composition (%) of the Co-Cr-Mo alloy

TABLE II Coefficients of dynamic friction of various bearing couples in previous studies

Figure 1. Chemical reaction on Co-Cr-Mo during polymerization of MPC.

Figure 2. FT-IR/ATR spectra of untreated Co-Cr-Mo and Co-Cr-Mo-*g*-MPC surfaces with a 0.50-mol/L MPC concentration and a 90-min photoirradiation time.

Figure 3. Surface elemental concentrations in the Co-Cr-Mo-*g*-MPC surface as a function of the photoirradiation time for various MPC concentrations in feeds. Bar: standard deviations.

Figure 4. Static-water contact angle of the Co-Cr-Mo-*g*-MPC surface as a function of the photoirradiation time for various MPC concentrations in feeds. Bar: standard deviations.

Figure 5. Cross-sectional TEM images of the Co-Cr-Mo-*g*-MPC surface with various MPC concentration in feeds and a 90-min photoirradiation time. Aluminun coating layers

(approximately 70 nm) for preparation of TEM observation specimen are shown above the poly(MPC) layer of the Co-Cr-Mo-*g*-MPC surface. In (a) and (c), small open-circles (P1–5) indicate EDX analysis points. Bar: 200 nm.

Figure 6. EDX spectra of the Co-Cr-Mo-*g*-MPC surface with a 0.5-mol/L MPC concentration and a 90-min photoirradiation time. The spectra were analyzed on the cross-section (P1–5) of the untreated Co-Cr-Mo and Co-Cr-Mo-*g*-MPC in Fig. 5.

Figure 7. Coefficients of dynamic friction for the various types of pins sliding against the untreated Co-Cr-Mo and Co-Cr-Mo-*g*-MPC plates. Bar: standard deviations.

Figure 8. Images of high-density grafted poly(MPC)/low-density grafted poly(MPC) and high-density grafted poly(MPC)/high-density grafted poly(MPC) bearing interfaces.

TABLE I Chemical composition (%) of the o-Cr-Mo alloy

Cr	Mo	C	Ni	Fe	Si	Mn	Al	Co
28.54	6.07	0.01	0.02	0.05	0.40	0.31	0.02	Bal.

TABLE II Coefficients of dynamic friction of various bearing couples in previous studies

Bearing couple		Friction coefficient	Reference
Pin	Disc or plate		
Co-Cr-Mo	Co-Cr-Mo	0.19 – 0.27	41, 53
UHMWPE	Co-Cr-Mo	0.05 – 0.13	41, 54, 55
CLPE-*g*-MPC	MPC "grafted to" Co-Cr-Mo	0.07 – 0.13	41
Cartilage	Stainless steel	0.01 – 0.05	58
Cartilage	Cartilage	0.02	59

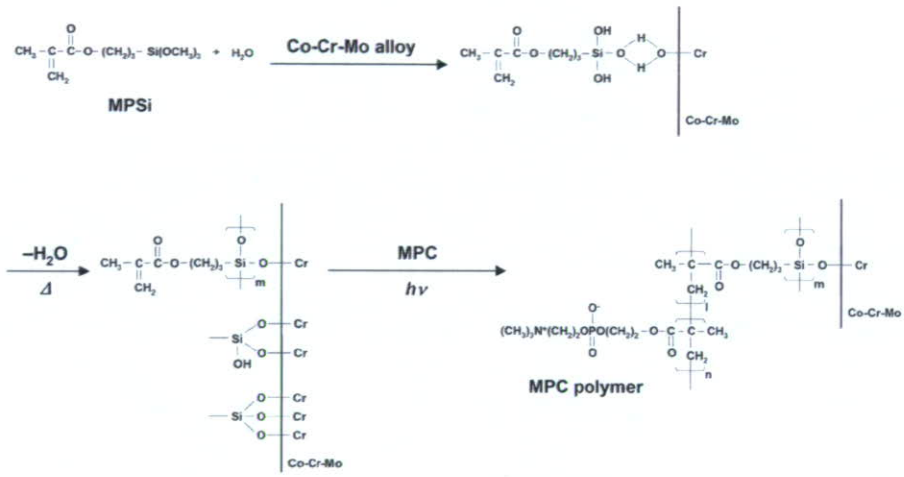


Figure 1. Chemical reaction on Co-Cr-Mo during polymerization of MPC.
61x34mm (600 x 600 DPI)

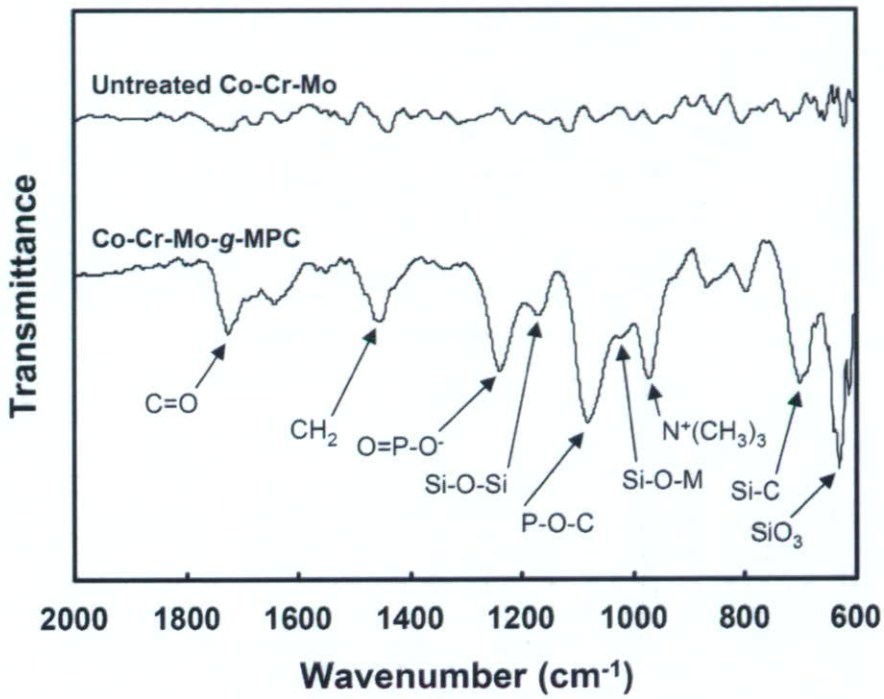


Figure 2. FT-IR/ATR spectra of untreated Co-Cr-Mo and Co-Cr-Mo-*g*-MPC surfaces with a 0.50-mol/L MPC concentration and a 90-min photoirradiation time.
61x49mm (600 x 600 DPI)

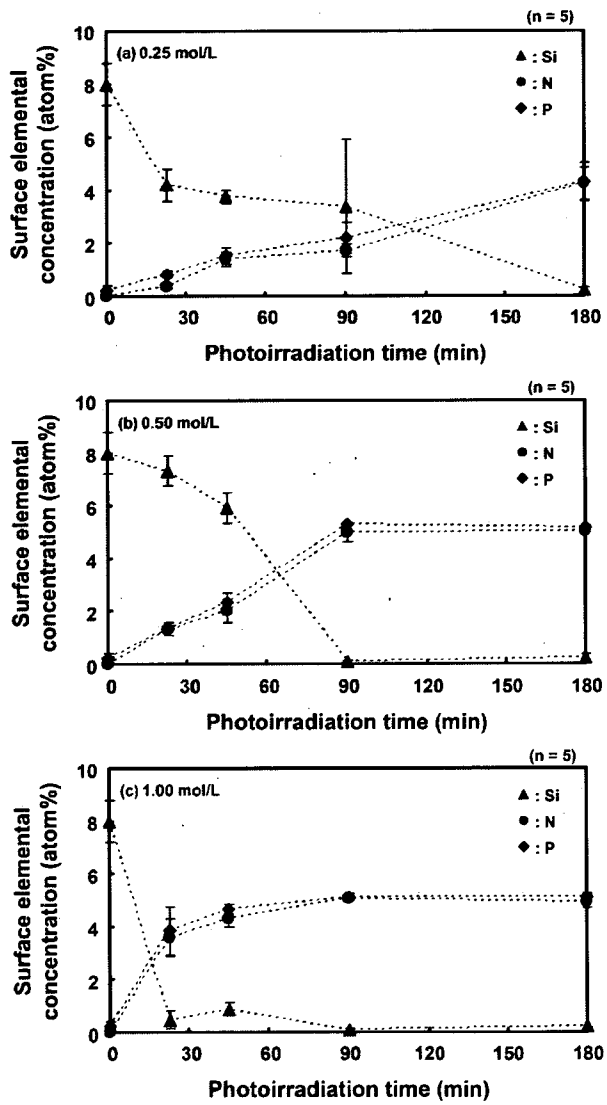


Figure 3. Surface elemental concentrations in the Co-Cr-Mo-*g*-MPC surface as a function of the photoirradiation time for various MPC concentrations in feeds. Bar: standard deviations.

152x272mm (600 x 600 DPI)

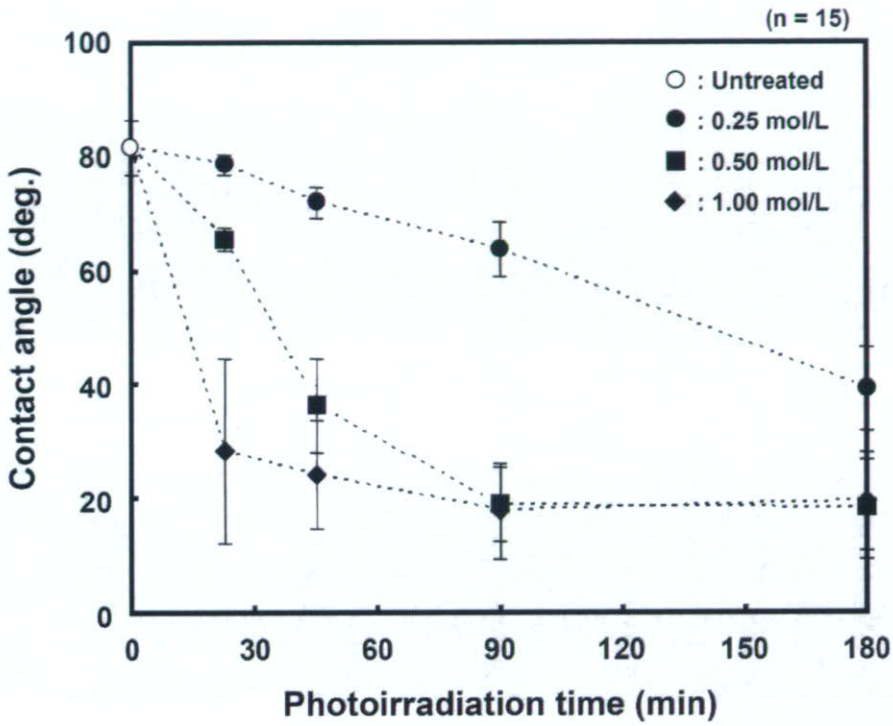
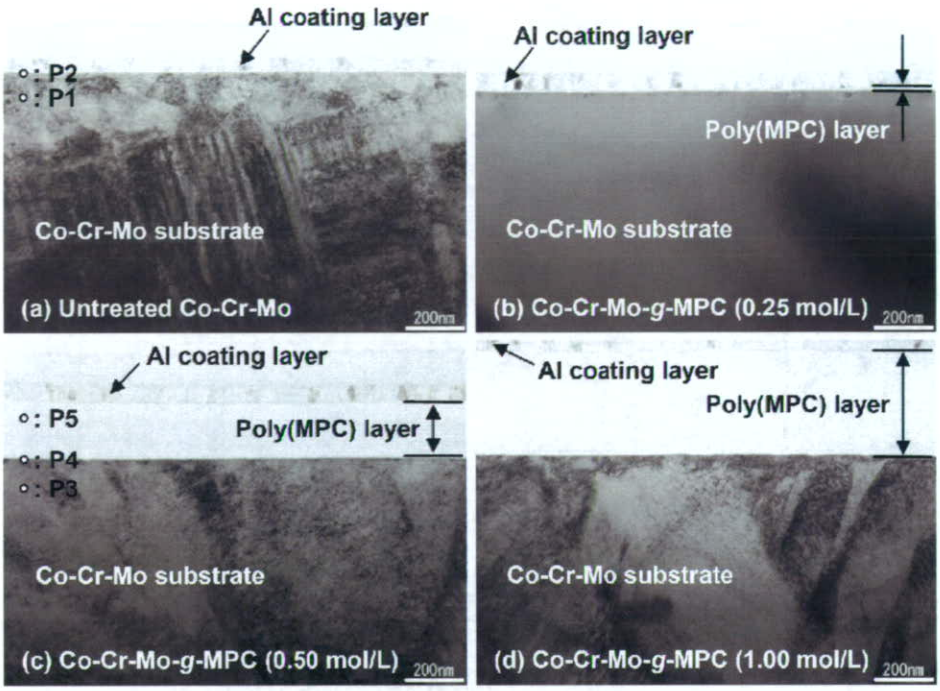


Figure 4. Static-water contact angle of the Co-Cr-Mo-*g*-MPC surface as a function of the photoirradiation time for various MPC concentrations in feeds. Bar: standard deviations.
66x53mm (600 x 600 DPI)



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82x62mm (600 x 600 DPI)

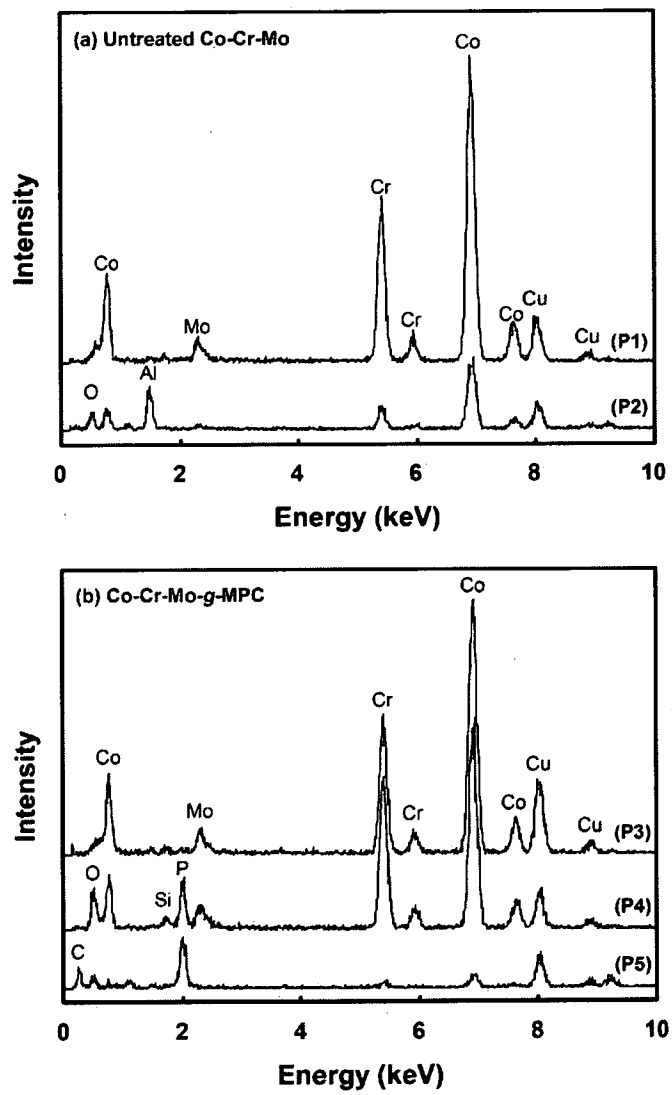

Figure 6. EDX spectra of the Co-Cr-Mo-*g*-MPC surface with a 0.5-mol/L MPC concentration and a 90-min photoirradiation time. The spectra were analyzed on the cross-section (P1–5) of the untreated Co-Cr-Mo and Co-Cr-Mo-*g*-MPC in Fig. 5.
123x194mm (600 x 600 DPI)

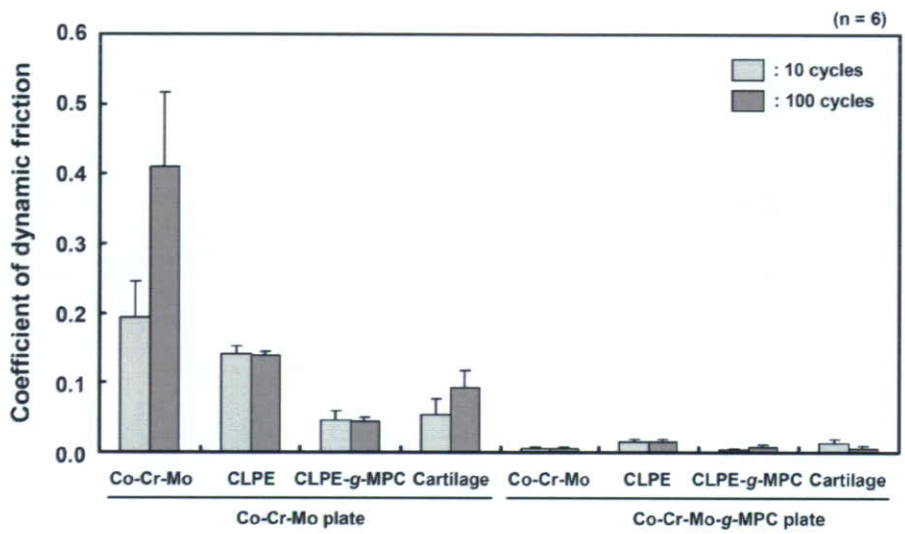

Figure 7. Coefficients of dynamic friction for the various types of pins sliding against the untreated Co-Cr-Mo and Co-Cr-Mo-*g*-MPC plates. Bar: standard deviations.
65x37mm (600 x 600 DPI)

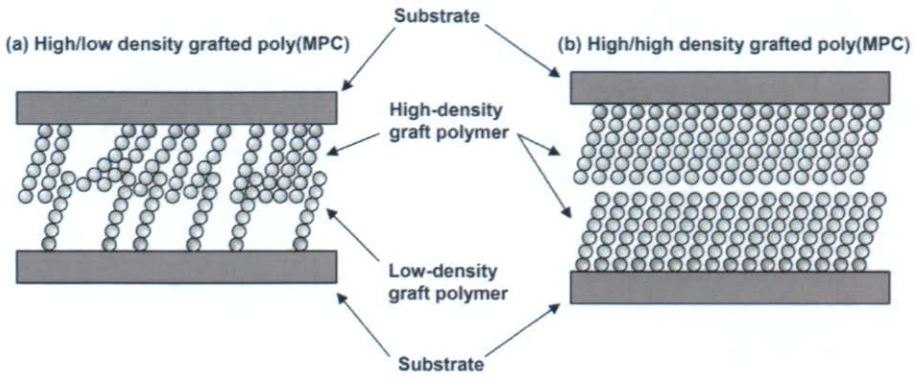

Figure 8. Images of high-density grafted poly(MPC)/low-density grafted poly(MPC) and high-density grafted poly(MPC)/high-density grafted poly(MPC) bearing interfaces.
45x19mm (600 x 600 DPI)

ポリエチレンライナー表面のMPC処理は人工股関節の弛みを抑制する

——ナノ表面制御による長寿命型人工股関節の開発——

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はじめに

人工股関節手術後に生じる弛み（loosening）はその長期予後を決定する重大かつ深刻な合併症である[1]。弛みは，人工股関節摺動面から生じる超高分子量ポリエチレン（ultra high molecular weight polyethylene：PE）の摩耗粉をマクロファージ（MΦ）が貪食して惹起される人工股関節周囲の骨吸収が主因である。摩耗粉を貪食したMΦはサイトカインやプロスタグランジン（PG）を分泌する。これらの生体活性物質は破骨細胞分化因子・receptor activator of NF-κB ligand（RANKL）の発現を誘導し，その結果破骨細胞の形成・活性化が促進され，人工股関節周囲の骨吸収に至る[2]。したがって，弛みの抑制を目指した研究は，摩耗粉を減少させること，あるいは骨吸収を抑制すること，の2つの方向性で検討されてきたが，現在までに決定的な解決策は得られていない。

我々は，摩耗粉の産生を抑制し，かつ摩耗粉による骨吸収の誘導を阻止すればこの問題を解決できると考えた。生体の関節軟骨表面にはナノスケールのリン脂質層が存在し潤滑機構の改善に寄与している[3]。そこで，生体適合性リン脂質ポリマー・2-methacryloyloxyethyl phosphorylcholine（MPC）ポリマーをPEライナー表面にナノスケールで光学的にグラフトする方法（MPCポリマー処理）を創案した（図1）。この処理は，紫外線を用いてMPCとPEの炭素原子同士に強力かつ安定な共有結合をさせるもので，表層のみの処理であり，基材であるPE自体には影響を及ぼさない[3]。我々は，本技術の臨床応用を目指し，耐摩耗性と摩耗粉が骨吸収に及ぼす影響の観点から関節摺動面のMPCポリマー

Grafting of biocompatible MPC polymer on the polyethylene liner for preventing loosening and improving longevity of the artificial hip joint

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Toru Moro et al.

Key words：人工股関節全置換術（total hip arthroplasty）
弛み（aseptic loosening）
オステオライシス（osteolysis）